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

Calendar Year 2014

Final Report

Prepared for:

The Port Authority of New York & New Jersey

Prepared by:

Southern Research Institute
Durham, NC

and

SC&A, Inc.
Vienna, VA

November 1, 2016

(This page intentionally left blank)

TABLE OF CONTENTS

Page

ACRONYMS AND ABBREVIATIONS VIII

1.0 INTRODUCTION 1
- 1.1 Background 1
- 1.2 Inventory Structure 2
- 1.3 Summary of GHG Emissions Results 8

2.0 STATIONARY COMBUSTION (SCOPE 1) 14
- 2.1 Buildings 14
- 2.2 Emergency Generators and Fire Pumps 19
- 2.3 Welding Gases 20

3.0 MOBILE COMBUSTION (SCOPE 1) 21
- 3.1 Central Automotive Division Fleet 21
- 3.2 PATH Diesel Equipment 25

4.0 FUGITIVE EMISSIONS (SCOPE 1) 27
- 4.1 Use of Refrigerants 27
- 4.2 Use of Fire Suppressants 30
- 4.3 Historic Elizabeth Landfill 31

5.0 PURCHASED ELECTRICITY (SCOPE 2) 33
- 5.1 Buildings 34
- 5.2 Rail Systems 39

6.0 PURCHASED STEAM, HEATING, AND COOLING (SCOPE 2) 41
- 6.1 JFK and AirTrain JFK 41
- 6.2 Port Authority Bus Terminal 42

7.0 ENERGY PRODUCTION (SCOPE 3) 44
- 7.1 Kennedy International Airport Cogeneration 44
- 7.2 Essex County Resource Recovery Facility 46

8.0 AIRCRAFT (SCOPE 3) 50
- 8.1 Aircraft Movements and Auxiliary Power Units 50
- 8.2 Ground Support Equipment 55

9.0 ATTRACTED TRAVEL (SCOPE 3) 57
- 9.1 Airport Passengers 57
- 9.2 Air Cargo 63

10.0 MOBILE COMBUSTION (SCOPE 3) 65
- 10.1 Ferry Movements 65
- 10.2 Shadow Fleet 70

11.0 REFERENCES 72

APPENDIX A: SCOPE 3 GHG EMISSIONS BY YEAR OF ASSESSMENT 77

LIST OF TABLES

Page

Table 1-1: Global Warming Potential Factors for Reportable GHGs 4
Table 1-2: Characterization of Sources under the Operational Control of the Port Authority 5
Table 1-3: Characterization of Tenant Sources 7
Table 1-4: Characterization of Customer Sources 8
Table 1-5: Characterization of Employee Sources 8
Table 1-6: Port Authority 2014 GHG Emissions Summary (metric tons CO_2e) 11
Table 1-7: Port Authority 2014 Biogenic GHG Emissions Summary 11
Table 1-8: Port Authority 2014 GHG Emissions by Line Department (metric tons CO_2e) 12
Table 1-9: Port Authority 2014 GHG Emissions by Emissions Category and Activity (metric tons CO_2e) 13
Table 2-1: Port Authority Facilities with Stationary Combustion 14
Table 2-2: Stationary Combustion Fuel Usages 15
Table 2-3: Stationary Combustion GHG Emission Factors 16
Table 2-4: Stationary Combustion CAP Emission Factors 16
Table 2-5: 2014 GHG Emissions from Stationary Combustion 17
Table 2-6: 2014 GHG Emissions from Stationary Combustion by Facility (metric tons) 17
Table 2-7: 2014 CAP Emissions from Stationary Combustion 18
Table 2-8: 2014 CAP Emissions from Stationary Combustion by Facility (metric tons) 18
Table 2-9: Emergency Generator and Fire Pump GHG and CAP Emission Factors 19
Table 2-10: 2014 GHG Emissions from Emergency Generators and Fire Pumps (metric tons) 20
Table 2-11: 2014 CAP Emissions from Emergency Generators (metric tons) 20
Table 3-1: 2014 CAD Fleet Fuel Consumption 21
Table 3-2: Standard Emission Factors for the CAD Fleet 23
Table 3-3: Effective CO_2 Emission Factors for the CAD Fleet 23
Table 3-4: 2014 GHG Emissions for Main Fleet Vehicles (metric tons) 24
Table 3-5: 2014 GHG Emissions for Non-Main Fleet Vehicles (metric tons) 24
Table 3-6: 2014 GHG Emissions for the CAD Fleet by Method (metric tons) 25
Table 3-7: 2014 CAP Emissions for the CAD Fleet (metric tons) 25
Table 3-8: 2014 GHG Emissions from PATH Diesel Equipment (metric tons) 26
Table 3-9: 2014 CAP Emissions from PATH Diesel Equipment (metric tons) 26
Table 4-1: Selection of Refrigerant Methodology Option by Facility in 2013 and 2014 29
Table 4-2: 2014 Refrigerant Emissions by Facility and Reportable GHG (metric tons CO_2e) 29
Table 4-3: Fire Protection Equipment by Facility and Suppressant Type 30
Table 4-4: 2014 GHG Emissions from the Historic Elizabeth Landfill 32
Table 5-1: Port Authority Facilities with Electricity Consumption 33

Table 5-2: Port Authority Facilities' Electricity Consumptions 33
Table 5-3: Electricity Consumption GHG Emission Factors 35
Table 5-4: Electricity Consumption CAP Emission Factors 36
Table 5-5: 2014 GHG Emissions from Electricity Consumption 36
Table 5-6: 2014 GHG Emissions from Electricity Consumption 37
Table 5-7: 2014 CAP Emissions for Electricity Consumption by Department (metric tons) 38
Table 5-8: 2014 CAP Emissions for Electricity Consumption 38
Table 5-9: 2014 GHG Emissions from Electricity Consumption 40
Table 5-10: 2014 CAP Emissions from Electricity Consumption 40
Table 6-1: 2014 KIAC GHG Emission Factors 41
Table 6-2: 2014 KIAC CAP Emission Factors 41
Table 6-3: 2014 GHG Emissions from KIAC Energy Purchases (metric tons) 42
Table 6-4: 2014 CAP Emissions from KIAC Energy Purchases (metric tons) 42
Table 6-5: Con Edison GHG and CAP Emission Factors 43
Table 6-6: 2014 PABT GHG Emissions from Con Edison 43
Table 6-7: 2014 PABT CAP Emissions from Con Edison 43
Table 7-1: Emission Factors for Natural Gas Combustion at Combined Cycle Power Plant 45
Table 7-2: 2014 KIAC Electricity and Thermal Emission Factors by Pollutant 45
Table 7-3: 2014 KIAC Production GHG Emissions Summary (metric tons) 46
Table 7-4: 2014 KIAC CAP Emissions Summary (metric tons) 46
Table 7-5: 2014 KIAC GHG and CAP Emissions Summary by End-User (metric tons) 46
Table 7-6: CAP Emission Factors for MSW Combustion 47
Table 7-7: CAP Emission Factors for No. 2 Fuel Oil Combustion 48
Table 7-8: 2014 Essex County Resource Recovery Facility GHG Emissions (metric tons) 48
Table 7-9: 2014 Essex County Resource Recovery Facility CAP Emissions (metric tons) 48
Table 7-10: GHG Emissions for Essex County Resource Recovery Facility, 2006–2014 49
Table 8-1: 2014 Port Authority Operations by Airport 51
Table 8-2: 2014 Average Taxi In and Taxi Out Times by Airport (minutes) 52
Table 8-3: 2014 Average Aircraft CH_4 and N_2O Emission Factors (kg/LTO) 52
Table 8-4: Methodology to Determine Default APU Run Time 53
Table 8-5: Gate Electrification and PCA Available at Port Authority Airports, 2014 53
Table 8-6: 2014 Aircraft GHG Emissions by Airport (metric tons) 54
Table 8-7: 2014 Aircraft CAP Emissions by Airport (metric tons) 54
Table 8-8: 2014 APU GHG Emissions by Airport (metric tons) 54
Table 8-9: 2014 APU CAP Emissions by Airport (metric tons) 54
Table 8-10: 2014 GSE GHG Emissions by Airport (metric tons) 56
Table 8-11: 2014 GSE CAP Emissions by Airport (metric tons) 56

Table 9-1: Percentage of Total Passengers on Connecting Flights, 2014 57
Table 9-2: One-Way Travel Distances Associated with Airport Facilities 58
Table 9-3: Average Travel Party Size by Travel Mode and Facility 60
Table 9-4: 2014 Airport Attracted Travel GHG Emissions by Mode (metric tons) 62
Table 9-5: 2014 Attracted Travel CAP Emissions by Mode (metric tons) 62
Table 9-6: 2014 Attracted Travel GHG Emissions by Airport (metric tons) 63
Table 9-7: 2014 Attracted Travel CAP Emissions by Airport (metric tons) 63
Table 9-8: One-Way Travel Distance Associated with JFK Airport for Cargo Travel 64
Table 9-9: 2014 Cargo Truck Attracted Travel GHG Emissions by Airport (metric tons) 64
Table 9-10: 2014 Cargo Truck Attracted Travel CAP Emissions by Airport (metric tons) 64
Table 10-1: WFC Schedules and Annual Running Times by Route 65
Table 10-2: Summary of Ferry Activity Data 66
Table 10-3: 2014 GHG Emissions from Ferries, by Route and Operating Mode (metric tons) 68
Table 10-4: 2014 CAP Emissions from Ferries, by Route and Operating Mode (kilograms) 69
Table 10-5: Idling Time per Route as Percent of Daily Ferry-Hours 69
Table 10-6: 2014 Shadow Fleet GHG Emissions by Airport (metric tons) 71
Table 10-7: 2014 Shadow Fleet CAP Emissions by Airport (metric tons) 71

LIST OF FIGURES

Figure 1-1. Schematic of the Port Authority's Inventory Boundary....3
Figure 1-2. 2014 GHG Inventory Comparison with the 2006 Baseline....9
Figure 1-3. 2014 Operational Control GHG Emissions Comparison with the 2006 Baseline....10
Figure 2-1: 2014 GHG Emissions Distribution from Stationary Combustion by Department....17
Figure 3-1: Recordkeeping for CAD Fleets....22
Figure 4-1: Selection of Method to Quantify Fugitive Emissions from AC Equipment....28
Figure 5-1: 2014 CO_2e Emissions from Electricity Consumption by Department....37
Figure 7-1: Distributed Emissions Methodology....45

ACRONYMS AND ABBREVIATIONS

AC	air conditioning
AEDT	Aviation Environmental Design Tool
AMT	Auto Marine Terminal
APU	Auxiliary Power Unit
ATADS	Air Traffic Activity Data System
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.
DF	deterioration factor
ECRR	Essex County Resource Recovery
EDMS	Emission and Dispersion Modeling System
EF	emission factor
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
EY	emission year
FAA	Federal Aviation Administration
FLIGHT	EPA's Facility Level Information on GreenHouse gases Tool
g	gram(s)
gal	gallon
GGRP	Greenhouse Gas Reporting Program
GHG	greenhouse gas
GRP	General Reporting Protocol
GSE	Ground Support Equipment
GW Bridge	George Washington Bridge
GWP	global warming potential
HCs	hydrocarbons
HCFC	hydrochlorofluorocarbon
HFCs	hydrofluorocarbons
hp	horsepower
hr	hour
hrs/yr	hours per year
HSRG	heat recovery steam generator
Hz	hertz
ICAO	International Civil Aviation Organization
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
LF	load factor
LGA	LaGuardia Airport
LSP	Liberty State Park
LTO	landing and take-off
MARKAL	EPA's MARKet ALlocation database
MMBtu	million British thermal units
MOVES	EPA's Motor Vehicle Emissions Simulator
MSW	municipal solid waste
MWh	megawatt hour(s)
National Grid	National Grid USA Service Company, Inc.
NYNNJLINA	New York/Northern New Jersey/Long Island Non-Attainment Area
N_2O	nitrous oxide
NA	not applicable
NG	natural gas
No.	number
NO_x	nitrogen oxides
NPCC	Northeast Power Coordinating Council
NQ	not quantified
NYC	New York City
NYCW	NPCC NYC/Westchester
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
PCA	preconditioned air
PCNJ	Port Commerce, New Jersey
PDF	portable document format
Pechan	former E.H. Pechan & Associates (now SC&A)
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
QA/QC	quality assurance/quality control
RECs	renewable energy certificates
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 Institute
SWF	Stewart International Airport
TCAP	Tenant Construction and Alteration Process manual
TCR	The Climate Registry
TEB	Teterboro Airport
TIM	times-in-mode

TPY	tons per year of pollutant
ULSD	ultra-low sulfur diesel
VALE	Voluntary Airport Low Emissions Program
VMT	vehicle miles traveled
VOCs	volatile organic compounds
WFC	World Financial Center
WIP	work in place
WTC	World Trade Center

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 and Bus Station; 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.

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 this policy is the dual goal of (a) reducing GHG emissions related to its facilities, including tenants and customers, by 80 percent from 2006 levels by 2050; and (b) pursuing a net zero GHG emissions goal for its operations (Port Authority 2008).

The Port Authority retained the services of Southern Research Institute (Southern) and SC&A, Inc. (formerly E.H. Pechan) to conduct annual emission inventories covering GHGs and co-pollutants that are collectively referred to as criteria air pollutants (CAP). The Port Authority's inventories follow international best practices for defining the inventory boundary in terms of an organizational and operational boundary, and further characterizing the operational boundary in terms of scope 1, scope 2, and scope 3 emissions (WRI 2004). A thorough discussion of the Port Authority's inventory structure is provided in Section 1.2.

The 2006 inventory was the first comprehensive assessment of GHG and CAP emissions and established the initial baseline for measuring progress toward the goals specified in the 2008 Environmental Sustainability Policy. The 2006 baseline was updated in 2007 and 2008; together these inventories helped the Port Authority map key emission sources by line department. The Port Authority sponsored a detailed 2009 emissions inventory for the newly acquired Stewart International Airport instead of a comprehensive inventory.

At the time of the 2010 inventory, the Port Authority became a member of The Climate Registry (TCR), a not-for-profit organization that assists its members to voluntarily measure, report, and verify their carbon footprints. The 2010 inventory received certification by an independent verification body attesting that the Port Authority's operational control GHG emissions inventory (i.e., scope 1 and scope 2) was complete, accurate, and transparent. Similarly, the Port Authority submitted the 2011 and 2012 inventories to TCR and had them independently verified.

For the 2013 inventory, the Port Authority revised and updated the criteria for scope 3 emissions to better align the characterization of scope 3 sources with the 2008 Environmental Sustainability Policy. This effort lead to the development of a definitive characterization of emission sources for all scopes of the operational boundary (i.e., scope 1, scope 2, and scope 3 sources) and inventory years assessed to-date. Building on the insight and experience gained from past inventories, the Port Authority is publishing this 2014 GHG and CAP inventory as a tool for evaluating the effects of ongoing mitigation actions and informing the design of future environmental and sustainability initiatives.

1.2 INVENTORY STRUCTURE

The structure of the Port Authority's GHG and CAP inventory conforms to the corporate accounting and reporting standard (GHG Protocol) published by the World Resources Institute and World Business Council for Sustainable Development (WRI 2004). Per the GHG Protocol, the Port Authority defined the inventory boundary in relation to its organizational and operational boundaries. The Port Authority sets the organizational boundary using the operational control approach. The GHG Protocol defines operational control as an organization "[having] the full authority to introduce and implement its operating policies at the operation" (WRI 2004). The Port Authority's operational boundary encompasses direct and indirect emissions as follows:

- Direct Scope 1 emissions resulting from the combustion of fuels by or fugitive losses from sources operated by the Port Authority (e.g., Port Authority owned and controlled vehicles, air conditioning equipment, emergency generators).
- Indirect Scope 2 emissions pertain to Port Authority energy acquisitions for the benefit of its operations but from sources not operated by the Port Authority (e.g., electricity purchases for the benefit of Port Authority operations).
- Indirect Scope 3 emissions relate to emissions from tenant and customer activities within or interacting with Port Authority owned facilities (e.g., aircraft movements during landing and take-off cycle below an altitude of 3,000 feet (ACRP, 2009)), vehicular movements across bridges and tunnels). This scope also includes emissions from Port Authority employee commuting.

To clarify the extent to which the Port Authority has influence over scopes 1, 2, and 3 emitting activities, a carbon

management dimension was added to the inventory boundary. At one end of the carbon management spectrum are activities over which the Port Authority has the most influence, such as energy acquisitions for the benefit of its own operations (e.g., natural gas, transportation fuels, electricity purchases). At the other end, there are activities over which the Port Authority has little influence, such as an employee's decision on mobility (e.g., use of personal vehicle versus mass transit for daily commuting). An illustration of the Port Authority's inventory boundary and key structural features is shown in Figure 1-1.

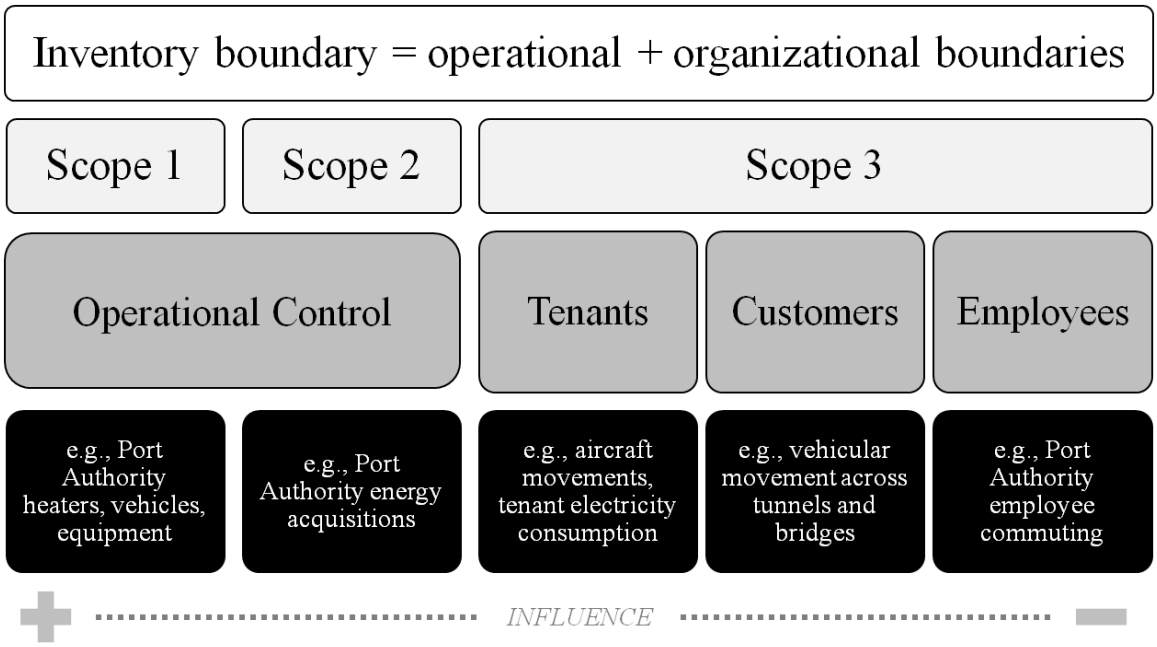

Figure 1-1. Schematic of the Port Authority's Inventory Boundary

1.2.1 Pollutant Coverage

The Port Authority inventory covers the six main GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Where applicable, the report also shows emissions in CO_2e, where the emissions of each pollutant are multiplied by their respective global warming potential (discussed in section 1.2.2) to express total radiative forcing effects in a single unit, with CO_2 as the reference gas. The inventory also quantifies key co-pollutants referred to collectively as criteria pollutants or CAPs; these include nitrogen oxides (NO_x), sulfur oxides (SO_x), 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 ($PM_{2.5}$).

1.2.2 Global Warming Potentials

The Intergovernmental Panel on Climate Change (IPCC) developed global warming potentials (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 TCR's General Reporting Protocol, GWP values from the Second Assessment Report were used and are presented in Table 1-1 (TCR 2013a).

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

Common Name	Formula	Chemical Name	GWP
Carbon dioxide	CO_2	NA	1
Methane	CH_4	NA	21
Nitrous oxide	N_2O	NA	310
Sulfur hexafluoride	SF_6	NA	23,900
Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	trifluoromethane	11,700
HFC-32	CH_2F_2	difluoromethane	650
HFC-41	CH_3F	fluoromethane	150
HFC-43-10mee	$C_5H_2F_{10}$	1,1,1,2,3,4,4,5,5,5-decafluoropentane	1,300
HFC-125	C_2HF_5	pentafluoroethane	2,800
HFC-134	$C_2H_2F_4$	1,1,2,2-tetrafluoroethane	1,000
HFC134a	$C_2H_2F_4$	1,1,1,2-tetrafluoroethane	1,300
HFC-143	$C_2H_3F_3$	1,1,2-trifluoroethane	300
HFC-143a	$C_2H_3F_3$	1,1,1-trifluoroethane	3,800
HFC-152	$C_2H_4F_2$	1,2-difluoroethane	43
HFC-152a	$C_2H_4F_2$	1,1-difluoroethane	140
HFC-161	C_2H_5F	fluorothane	12
HFC-227ea	C_3HF_7	1,1,1,2,3,3,3-heptafluoropropane	2,900
HFC-236cb	$C_3H_2F_6$	1,1,1,2,2,3-hexafluoropropane	1,300
HFC-236ea	$C_3H_2F_6$	1,1,1,2,3,3-hexafluoropropane	1,200
HFC-236fa	$C_3H_2F_6$	1,1,1,3,3,3-hexafluoropropane	6,300
HFC-245ca	$C_3H_3F_5$	1,1,2,2,3-pentafluoropropane	560
HFC-245fa	$C_3H_3F_5$	1,1,1,3,3-pentafluoropropane	950
HFC-365mfc	$C_4H_5F_5$	1,1,1,3,3-pentafluoropropane	890
Perfluorocarbons (PFCs)			
Perfluoromethane	CF_4	tetrafluoromethane	6,500
Perfluoroethane	C_2F_6	hexafluoroethane	9,200
Perfluoropropane	C_3F_8	octafluoropropane	7,000
Perfluorobutane	C_4F_{10}	decafluorobutane	7,000
Perfluorocyclobutane	c-C_4F_8	octafluorocyclobutane	8,700
Perfluoropentane	C_5F_{12}	dodecafluoropentane	7,500
Perfluorohexane	C_6F_{14}	tetradecafluorohexane	7,400

Source: IPCC 1996.

1.2.3 Operational Control Emissions

Emissions that fall under the operational control of the Port Authority include direct scope 1 emissions and indirect scope 2 emissions as defined by the GHG Protocol (WRI 2004). The Port Authority sponsors annual assessments of scope 1 and scope 2 emissions for the purpose of tracking progress towards the goal of carbon neutrality for Port Authority operations. To that end, the Port Authority selects emission estimation methods that yield very accurate results and ensure that the operational control inventory meets a materiality standard of 5 percent (i.e., the sum of errors and misstatements do not exceed 5 percent of total emissions). The Port Authority successfully registered the 2010, 2011, and 2012 scope 1 and scope 2 inventories with TCR. As part of the TCR registration, these GHG inventories were independently verified to be complete, transparent, and materially accurate. Since 2015, the Port Authority also voluntarily discloses its carbon footprint to CDP, a not-for-profit organization that provides a global system for companies and cities to measure, disclose, manage and share vital environmental information.

The characterization of emission sources under the operational control of the Port Authority is presented in Table 1-2. Emission sources are grouped by general emission categories, including stationary and mobile combustion; purchased heating, cooling and steam; and fugitive emissions. In addition, a range of activities associated with these emission categories is provided. “Buildings” represents emissions from energy consumption (e.g., natural gas or electricity) at Port Authority facilities. “Emergency Generators and Fire Pumps” corresponds to emissions from fuel combustion by emergency response equipment. “Rail Systems” refers to emissions from energy acquisitions for the operation of various light rail lines and stations. Emissions from combustion of transportation fuels by the Port Authority’s Central Automotive Division fleet are referred to as the “CAD fleet,” and emissions from combustion of fuels for operation of non-road equipment along the PATH system are labeled “PATH Non-Road Equipment.” “Refrigeration/Fire Suppression” refers to unintentional releases of refrigerant from air conditioning equipment and intentional releases from specialty fire suppression systems. “Landfill Gas” is associated with fugitive emissions from a closed landfill on Port Elizabeth. “Welding” refers to emissions that stem from routine maintenance operations.

Table 1-2 also identifies for each emitting activity the corresponding scope and indicates whether biogenic emissions are also generated. For the Port Authority, biogenic emissions are the result of bioethanol and biodiesel fuel consumption by the CAD fleet and CO_2 fugitive emissions from the closed Elizabeth Landfill.

Table 1-2: Characterization of Sources under the Operational Control of the Port Authority

Emission Category	Activity	Scope		
		1	2	Biogenic
Stationary Combustion	Buildings	✓		
	Emergency Generators and Fire Pumps	✓		
	Welding	✓		

Table 1-2: Characterization of Sources under the Operational Control of the Port Authority				
Emission Category	**Activity**	**Scope**		
		1	**2**	**Biogenic**
Mobile Combustion	CAD Fleet	✓		✓
	PATH Non-Road Equipment	✓		
Purchased Electricity	Buildings		✓	
	Rail Systems		✓	
Purchased Cooling	Buildings		✓	
	Rail Systems		✓	
Purchased Heating	Buildings		✓	
	Rail Systems		✓	
Purchased Steam	Buildings		✓	
Fugitive Emissions	Landfill Gas	✓		✓
	Refrigeration/Fire Suppression	✓		

1.2.4 Scope 3 Emissions - Tenants

The Port Authority promotes commerce and regional economic development with the help of partners, tenants, and contractors (hereinafter referred to as "tenants"). In general, tenants conduct business within Port Authority facilities (e.g., operation of cargo handling equipment in maritime terminals) or interact directly with Port Authority infrastructure (e.g., aircraft movements). Emissions from tenant activities fall outside the Port Authority's operational control, and therefore are classified as scope 3. Emission estimates for tenant sources are based on best available methods and data sources. In some cases, these estimates have a margin of error of less than 5 percent, but in most cases, tenant emission estimates do not subscribe to a 5 percent materiality standard. Assessing tenant emissions helps the Port Authority identify environmental and sustainability initiatives that can best be achieved in collaboration with its tenants.

The characterization of tenant emission sources is presented in Table 1-3. Emission sources are grouped by general emission categories, including stationary and mobile combustion; purchased heating, cooling and steam; and aircrafts. In addition, a range of activities associated with these emission categories is provided. "Buildings" corresponds to emissions from tenant energy consumption (e.g., natural gas or electricity). "Cargo Handling Equipment" points to emissions from fuel combustion by cargo processing equipment at maritime ports. "Ferry Movements" are mobile emissions from ferry operations that arrive to and depart from the Port Authority's World Financial Center (WFC) terminal. "Rail Locomotive" refers to mobile emissions from such equipment on Port Authority property. "Shadow Fleet" corresponds to mobile emissions from vehicles owned by, but not operated by, the Port Authority. "Auto Marine Terminal, Vehicle Movements" are mobile emissions from staging imported vehicles on the premises of the Auto Marine Terminal (AMT). "Non-Road Diesel Engines" reflects emissions from diesel construction equipment activity on Port Authority sponsored sites. "Aircraft Movements" account for emissions from aircraft engines during a landing and take-off cycle. "Auxiliary Power Units" are emissions from aircraft auxiliary engines used to provide lighting and air conditioning at the terminal gate. Finally, "Ground Support

Equipment" refers to emissions from equipment used to service aircrafts between flights.

Table 1-3: Characterization of Tenant Sources			
Emission Category	**Activity**	**Scope**	
		3	**Biogenic**
Stationary Combustion	Buildings	✓	
Mobile Combustion	Ferry Movements	✓	✓
	Rail Locomotives	✓	
	Cargo Handling Equipment	✓	
	Shadow Fleet	✓	
	AMT, Vehicle Movements	✓	
Purchased Electricity	Buildings	✓	
Purchased Cooling	Buildings	✓	
Purchased Heating	Buildings	✓	
Construction	Non-Road Diesel Engines	✓	
Aircrafts	Aircraft Movements	✓	
	Auxiliary Power Units	✓	
	Ground Support Equipment	✓	

1.2.5 Scope 3 Emissions - Customers

The Port Authority promotes commerce and regional economic development for the benefit of the public (hereinafter referred to as "customers"). Emissions from customer activities fall outside the Port Authority's operational control, and are therefore classified as scope 3. Emission estimates for customer sources are based on best available methods and data sources, but customer emission estimates do not subscribe to a 5 percent materiality standard. Assessing customer emissions helps the Port Authority consider carbon and air pollution impacts stemming from utilization of its infrastructure, and may inform decision-makers on the selection and design of future capital projects.

The characterization of customer emission sources is presented in Table 1-4. Emission sources are grouped by general emission categories, including attracted travel and energy production. Attracted travel refers to customer motorized travel to access Port Authority infrastructure and includes a range of activities. The category "Drayage Trucks" covers emissions from drayage trucks moving cargo inland from the maritime ports. "Commercial Marine Vessels" refers to emissions from vessels that call on Port Authority ports. "Airport Passenger" accounts for emissions from motorized travel to access Port Authority air terminals. "Air Cargo" pertains to emissions associated with the distribution of cargo shipping to and from Port Authority airports. "Through Traffic" describes emissions from vehicles that travel across Port Authority tunnels, bridges and bus terminals. "Queued Traffic" accounts for emissions from vehicular congestion when the demand for a given tunnel or bridge exceeds its capacity. "Electricity Sold to Market" accounts for emissions from electricity that is generated in Port Authority-owned power plants, but consumed downstream by a non-specified end-user through the electricity market. This category excludes electricity

produced in a Port Authority-owned power plant and consumed by the Port Authority or a Port Authority tenant. Note that electricity production at the Essex County Resource Recovery plant is generated primarily from the combustion of municipal solid waste, which qualifies by federal and NJ state law as biogenic emissions.

Table 1-4: Characterization of Customer Sources

Emission Category	Activity	Scope	
		3	Biogenic
Attracted Travel	Drayage Trucks	✓	
	Commercial Marine Vessels	✓	
	Airport Passenger	✓	
	Air Cargo	✓	
	Through Traffic	✓	
	Queued Traffic	✓	
Energy Production	Electricity Sold to Market	✓	✓

1.2.6 Scope 3 Emissions - Employees

The Port Authority includes in its scope 3 boundary emissions associated with the commuting of its employees. The Port Authority regularly conducts anonymous employee surveys to collect information about commuting habits, including but not limited to distance, mode, origin and destination. Through these surveys, the Port Authority gathers feedback about proposed initiatives affecting employee commuting.

Table 1-5: Characterization of Employee Sources

Emission Category	Activity	Scope	
		3	Biogenic
Mobile Combustion	Employee Commuting	✓	✓

1.3 SUMMARY OF GHG EMISSIONS RESULTS

This section presents the results of the 2014 GHG inventory for anthropogenic emissions, unless otherwise specified. CAP emissions were estimated as co-pollutants and those emissions results are presented thematically at the end of each chapter.

In 2014, the Port Authority had a total carbon footprint (scopes 1+2+3) of 5,717 thousand metric tons CO_2e. This represents a decrease of 0.6 percent relative to the 2006 baseline. Since 2006, the Port Authority has achieved notable emission reductions in scope 2 emissions through the implementation of energy efficiency and energy conservation initiatives. Additionally, the Port Authority has kept scope 3 emission in check despite growing customer demand for Port Authority infrastructure in recent years. For instance, cargo volumes processed at the maritime ports have increased by 15 percent between 2006 and 2014 from 5.0 to 5.8 million twenty-foot equivalent units (Port Authority, 2015e). Similarly, passenger access to the PATH system increased from 67 to 74 million

annual passengers between 2006 and 2014. A comparison of the 2014 carbon footprint with the 2006 baseline is presented in Figure 1-2.

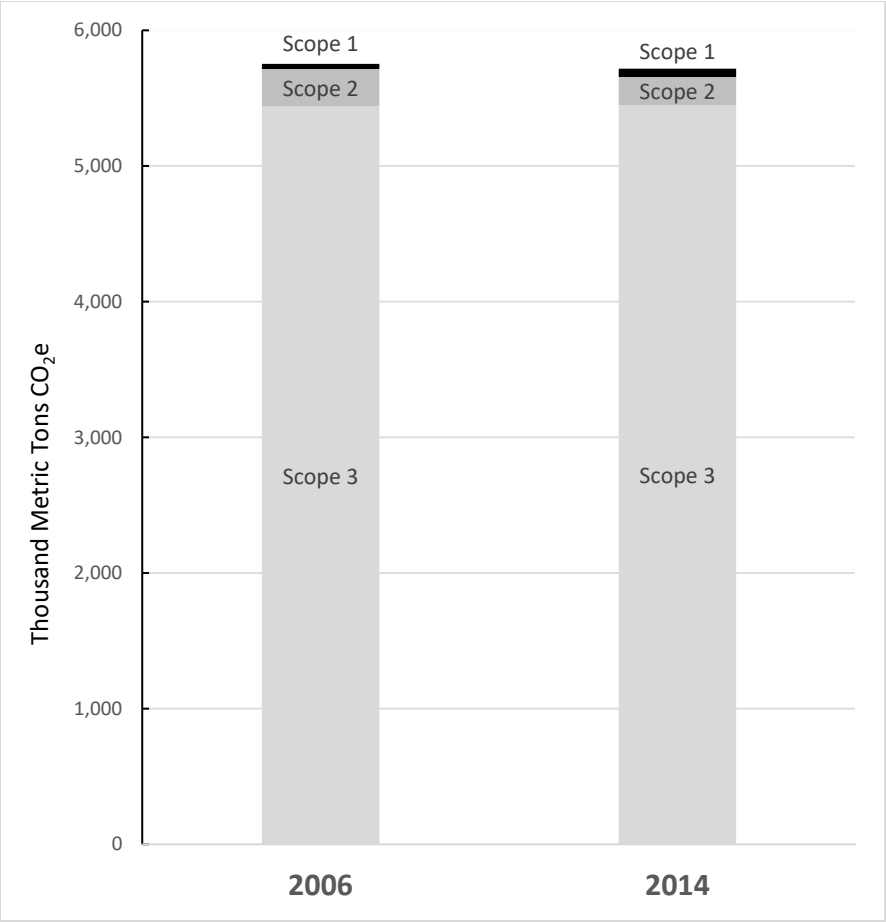

Figure 1-2. 2014 GHG Inventory Comparison with the 2006 Baseline

The carbon footprint of the Port Authority's operations (scopes 1+2) amounted to 268,622 metric tons of CO_2e in 2014. The Port Authority achieved a reduction of 43,627 metric tons CO_2e through changes in operations and implementation of numerous sustainability initiatives. This level of carbon mitigation corresponds to a 14 percent reduction relative to the 2006 base year. The goal of achieving carbon neutrality for Port Authority operations is attainable with the help of market instruments and additional operational improvements. Most notably, 72 percent of emissions could be mitigated by retiring renewable energy certificates (RECs) against 507,746 MWh of scope 2 electricity purchases from non-renewable sources. An additional 5 percent of emissions could be mitigated by means of fuel switching to biofuels and/or further electrification of the CAD fleet. Residual emissions accounting for 23 percent of the operational control inventory could be offset with the purchases of high quality carbon credits in the voluntary carbon market. A comparison of the 2014 and 2006 operation control GHG emission inventories is shown in Figure 1-3.

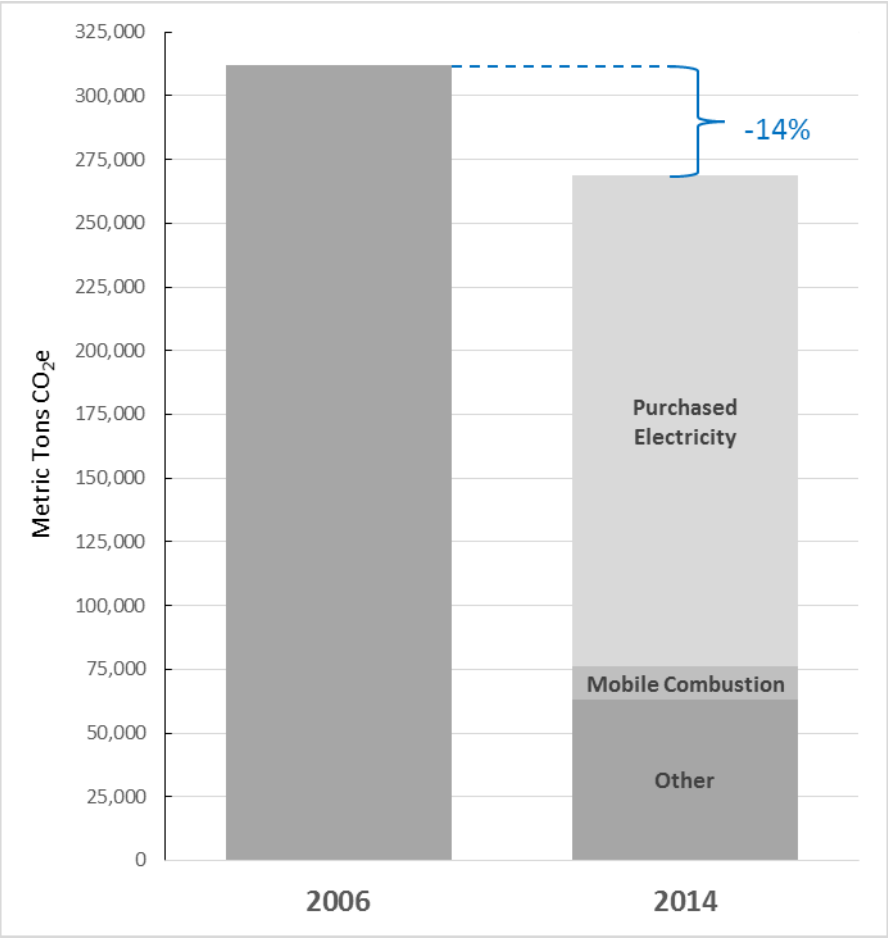

Figure 1-3. 2014 Operational Control GHG Emissions Comparison with the 2006 Baseline

The breakdown of emissions by carbon management level and scope is presented in Table 1-6. Total GHG emissions in the Port Authority's inventory are 5,717,389 metric tons CO_2e. Customer emissions account for over half of total emissions (55.7 percent), followed by tenant emissions (41.1 percent). Operational control emissions are relatively small, amounting to less than 5 percent. Employee emissions are the smallest, making up less than 1 percent of the entire Port Authority inventory. Note that the Port Authority inventory program requires that emissions from scope 1 and scope 2 sources be conducted annually and assessment of scope 3 emissions to be done periodically. For that reason, total scope 3 emissions of 5,448,766 metric tons CO_2e for 2014 represent a composite value of the most recent assessment for a given source. An account of scope 3 emission estimates by year of assessment is provided as supplemental information in Appendix A.

Table 1-6: Port Authority 2014 GHG Emissions Summary (metric tons CO_2e)					
Carbon Management Level	**Scope 1**	**Scope 2**	**Scope 3[a]**	**Total**	**Total %**
Operational Control	61,856	206,766		268,622	4.7%
Tenants			2,369,099	2,369,099	41.4%
Customers			3,058,314	3,058,314	55.7%
Employees			21,353	21,353	0.3%
Total	**61,856**	**206,766**	**5,448,766**	**5,717,389**	**100.0%**

[a] The sum of scope 3 emissions reflects emission values for the most recent assessment of a given source.

In conformance with the GHG Protocol, the Port Authority reports biogenic emissions separately. Within the Port Authority inventory boundary, there are multiple sources of biogenic emissions, including CO_2 bi-product of municipal solid waste decomposition released from the closed Elizabeth Landfill and combustion of biofuels by the CAD fleet, shadow fleet, and vehicles used by commuting employees. Most biogenic emissions come from energy recovery activities at the Essex County Resource Recovery facility, where municipal solid waste is combusted. A summary of biogenic emissions is presented in Table 1-7.

Table 1-7: Port Authority 2014 Biogenic GHG Emissions Summary		
Carbon Management Level	**Source**	**Biogenic**
Operational Control	Elizabeth Landfill	625
	CAD Fleet	1,718
Tenants	Shadow Fleet	1,442
Customers	Essex County Resource Recovery	502,447
Employees	Employee Commuting	915
Total		**507,146**

Table 1-8 presents anthropogenic emissions by line department and emissions categories across the carbon management spectrum. Sources grouped as Multi-Department include mobile combustion emissions from employees commuting to various Port Authority facilities and stationary combustion emissions from the maintenance and use of emergency generators and fire pumps located across the entire organization. Emissions from sources not expressly affiliated with one department such as electricity purchases and heating in support of central administrative functions are denoted as Central Administration.

Table 1-9 summarizes the Port Authority's anthropogenic GHG emissions by emission category and emitting activity across the carbon management spectrum. For the Drayage Truck activity under Attracted Travel, this report accounts for emissions to the first point of rest to a maximum distance of 400 miles, which is about the distance travelled on a full tank of diesel by a drayage truck in a day. The first point of rest boundary reflects an industry good-practice for the management of GHG emissions (WPCI, 2010). Drayage Truck emissions in this report compliments the results of the Port Commerce Department's 2014 Multi-Facility Emission Inventory (Starcrest, 2016) by estimating incremental emissions from the 16-county NYNJLINA boundary to the first point of rest.

Table 1-8: Port Authority 2014 GHG Emissions by Line Department (metric tons CO_2e)						
Department/Emissions Category	**Scope 1**	**Scope 2**	**Scope 3**			**Total**
	Ops. Control		*Tenants*	*Customers*	*Employees*	
Aviation	**34,462**	**114,798**	**2,040,489**	**985,762**		**3,175,512**
Aircraft			1,831,509			1,831,509
Attracted Travel				831,952		831,952
Energy Production				153,810		153,810
Fugitive Emissions	1,042					1,042
Purchased Cooling		6,095	11,452			17,546
Purchased Electricity		105,194	162,199			267,393
Purchased Heating		3,509	9,329			12,838
Stationary Combustion	33,420		26,001			59,421
Central Administration	**14,414**	**8,492**	**12,714**			**35,620**
Fugitive Emissions	259					259
Mobile Combustion	12,697		12,714			25,411
Purchased Electricity		8,492				8,492
Stationary Combustion	1,459					1,459
Engineering			**15,849**			**15,849**
Construction			15,849			15,849
Multi-Department	**673**				**21,353**	**22,026**
Mobile Combustion					21,353	21,353
Stationary Combustion	673					673
PATH	**4,558**	**44,328**	**99**	**60,064**		**109,049**
Attracted Travel				60,064		60,064
Fugitive Emissions	1,328					1,328
Mobile Combustion	319					319
Purchased Electricity		44,328	70			44,398
Stationary Combustion	2,911		30			2,940
Planning			**11,794**			**11,794**
Mobile Combustion			11,622			11,622
Purchased Electricity			123			123
Stationary Combustion			50			50
Port Commerce	**4,558**	**7,826**	**133,821**	**1,106,796**		**1,253,001**
Attracted Travel				1,106,796		1,106,796
Fugitive Emissions	3,924					3,924
Mobile Combustion			122,949			122,949
Purchased Electricity		7,826	7,615			15,441
Stationary Combustion	634		3,257			3,891
Real Estate	**127**	**2,774**	**151,688**	**359,652**		**514,241**
Energy Production				359,652		359,652
Purchased Electricity		2,774	104,162			106,937
Stationary Combustion	127		47,525			47,652
Tunnels, Bridges & Bus Terminals	**3,064**	**28,547**	**2,644**	**546,040**		**580,296**
Attracted Travel				546,040		546,040
Fugitive Emissions	8					8
Purchased Electricity		23,910	2,281			26,191
Purchased Steam		4,637				4,637
Stationary Combustion	3,056		364			3,420
Total	**61,856**	**206,766**	**2,369,099**	**3,058,314**	**21,353**	**5,717,389**

Table 1-9: Port Authority 2014 GHG Emissions by Emissions Category and Activity (metric tons CO_2e)						
Emissions Category and Activity	**Scope 1**	**Scope 2**	**Scope 3**			**Total**
	Ops. Control		*Tenants*	*Customers*	*Employees*	
Aircraft			**1,831,509**			**1,831,509**
Aircraft Movements			1,625,013			1,625,013
Auxiliary Power Units			31,920			31,920
Ground Support Equipment			174,576			174,576
Attracted Travel				**2,544,852**		**2,544,852**
Air Cargo				55,452		55,452
Airport Passenger				776,501		776,501
Commercial Marine Vessels				154,996		154,996
Drayage Trucks				951,799		951,799
PATH Passenger				60,064		60,064
Queued Traffic				22,107		22,107
Through Traffic				523,933		523,933
Construction			**15,849**			**15,849**
Non-Road Diesel Engines			15,849			15,849
Energy Production				**513,462**		**513,462**
Electricity Sold to Market				513,462		513,462
Fugitive Emissions	**6,561**					**6,561**
Landfill Gas	3,912					3,912
Refrigeration/Fire Suppression	2,649					2,649
Mobile Combustion	**13,015**		**147,285**		**21,353**	**181,654**
Auto Marine Terminal, Vehicle			402			402
CAD Fleet	12,697					12,697
Cargo Handling Equipment			104,525			104,525
Employee Commuting					21,353	21,353
Ferry Movements			11,622			11,622
PATH Non-Road Equipment	319					319
Rail Locomotives			18,022			18,022
Shadow Fleet			12,714			12,714
Purchased Cooling		**6,095**	**11,452**			**17,546**
Buildings		5,390	11,452			16,842
Rail Systems		704				704
Purchased Electricity		**192,525**	**276,449**			**468,974**
Buildings		131,055	276,449			407,504
Rail Systems		61,470				61,470
Purchased Heating		**3,509**	**9,329**			**12,838**
Buildings		2,727	9,329			12,056
Rail Systems		782				782
Purchased Steam		**4,637**				**4,637**
Buildings		4,637				4,637
Stationary Combustion	**42,279**		**77,226**			**119,505**
Buildings	41,606		77,226			118,832
Emergency Generators and Fire	672					672
Welding	1					1
Total	**61,856**	**206,766**	**2,369,099**	**3,058,314**	**21,353**	**5,717,389**

2.0 STATIONARY COMBUSTION (SCOPE 1)

2.1 BUILDINGS

The 2014 inventory considered buildings (including, but not limited to, Port Authority Central Administration buildings) where fuel was combusted to produce heat or motive power using equipment in a fixed location. Natural gas is the predominant fuel for building heating and in some facilities Number (No.) 2 fuel oil is used. Table 2-1 lists Port Authority facilities where fuel was combusted during 2014. Note that not every building within the Port Authority's operational boundary combusts fuel; therefore, Table 2-1 only lists facilities where stationary combustion occurs.

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	PSEG
George Washington Bridge	Natural Gas	PSEG
George Washington Bridge Bus Station	Natural Gas	Con Edison
Goethals Bridge	Natural Gas	National Grid
Holland Tunnel	Natural Gas	PSEG and Con Edison
Howland Hook	Natural Gas	National Grid
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 No. 2 Fuel Oil	PSEG
Port Authority Bus Terminal	Natural Gas	Con Edison
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 applicable

building in units of 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 were provided by the Port Authority in the form of gallons of fuel oil consumed, by month, for each building.

Table 2-2: Stationary Combustion Fuel Usages

Facility	Fuel Types Used	Amount Consumed
225 PAS	Natural Gas	12,527 therms
777 Jersey Ave	Natural Gas	63,897 therms
AirTrain JFK	Natural Gas	65,682 therms
Bayonne Bridge	Natural Gas	10,677 therms
Brooklyn Marine Terminal	Natural Gas	49,905 therms
EWR	Natural Gas	2,466,524 therms
George Washington Bridge	Natural Gas	147,699 therms
George Washington Bridge Bus Station	Natural Gas	148,215 therms
Goethals Bridge	Natural Gas	91,131 therms
Holland Tunnel	Natural Gas	125,348 therms
Howland Hook	Natural Gas	10,999 therms
JFK	Natural Gas	2,369,026 therms
	No. 2 Fuel Oil	86,357 gallons
LGA	Natural Gas	793,590 therms
	No. 2 Fuel Oil	91,539 gallons
Lincoln Tunnel	Natural Gas	28,696 therms
Outerbridge Crossing	Natural Gas	17,475 therms
PATC	Natural Gas	197,818 therms
PATH Buildings	Natural Gas	482,840 therms
	No. 2 Fuel Oil	33,380 gallons
Port Authority Bus Terminal	Natural Gas	5,271 therms
PCNJ	Natural Gas	58,360 therms
SWF	Natural Gas	145,724 ccf
TEB	Natural Gas	95,893 therms
The Teleport	Natural Gas	23,825 therms

2.1.2 Method

The GHG emission factors used to calculate the GHGs associated with stationary fuel combustion in buildings are shown in Table 2-3. The values in Table 2-3 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 2-4, an average high heating value of 1,026 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 2-3: Stationary Combustion GHG Emission Factors

Units	CO_2	CH_4	N_2O
Kilograms (kg)/ccf of natural gas (NG)	5.44	4.87×10^{-4}	9.23×10^{-6}
kg/therm of NG	5.31	4.75×10^{-4}	9×10^{-6}
kg/gallon of No. 2 Fuel Oil	10.21	1.38×10^{-3}	8.28×10^{-5}

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 sulfur dioxide (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 2-4.

Table 2-4: Stationary Combustion CAP Emission Factors

Units	SO_2	NO_x	PM total
kg/ccf of NG	2.72×10^{-5}	4.53×10^{-3}	3.45×10^{-4}
kg/therm of NG	2.65×10^{-5}	4.42×10^{-3}	3.36×10^{-4}
kg/gallon of No. 2 Fuel Oil	1.29×10^{-2}	9.07×10^{-3}	1.50×10^{-3}

2.1.3 Results

Emission 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 and 2013. In accordance with GRP guidelines, emission estimates developed from engineering calculations or a simplified estimation method (SEM) are distinguished from those using the GRP standard method.

Table 2-5 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 CO_2e related to stationary combustion, because the Port Authority assumes responsibility for heating large portions of terminal space. Table 2-6 identifies stationary combustion emissions by facility. CAP emissions totals are given by department and facility

in Table 2-7 and Table 2-8, respectively.

Table 2-5: 2014 GHG Emissions from Stationary Combustion by Department (metric tons)				
Department	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Aviation	33,335	3.0671	0.0682	33,420
PATH	2,903	0.2754	0.0071	2,911
Tunnels, Bridges, and Bus Terminals	3,048	0.2729	0.0052	3,056
Central Administration	1,455	0.1303	0.0025	1,459
Port Commerce	633	0.0567	0.0011	634
Real Estate	126	0.0113	0.0002	127
Total	**41,500**	**3.8136**	**0.0842**	**41,606**

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

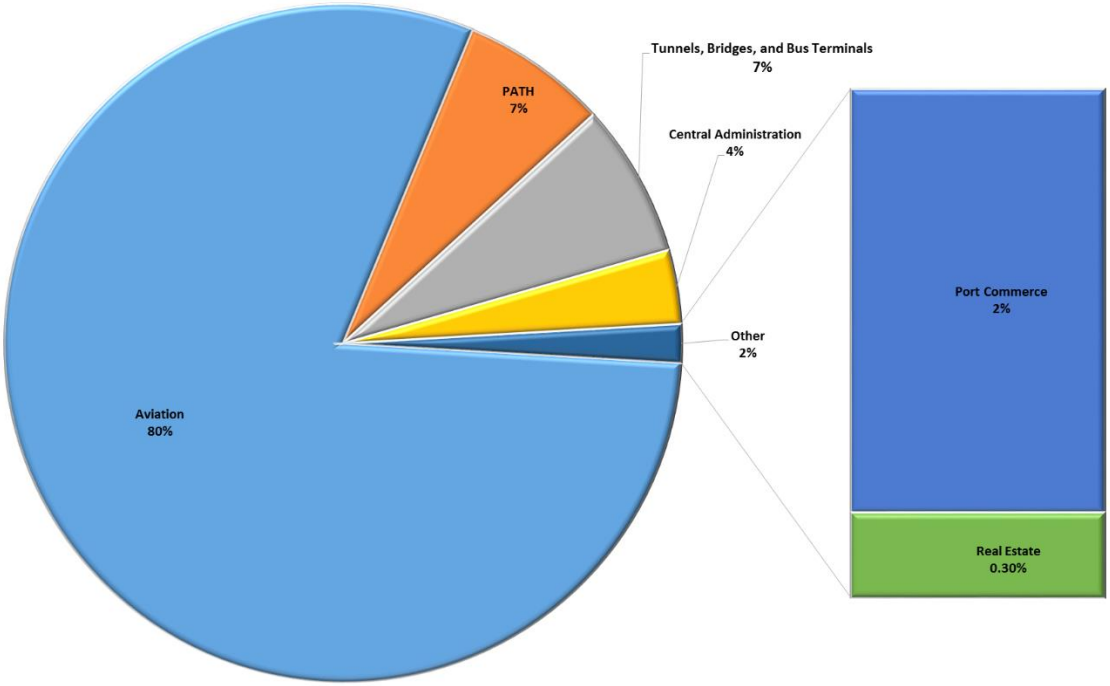

Figure 2-1: 2014 GHG Emissions Distribution from Stationary Combustion by Department

Table 2-6: 2014 GHG Emissions from Stationary Combustion by Facility (metric tons)				
Building/Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
225 PAS	66	0.0060	0.0001	67
777 Jersey	339	0.0304	0.0006	340
AirTrain JFK	349	0.0312	0.0006	349
Bayonne Bridge	57	0.0051	0.0001	57
Brooklyn Marine Terminal	265	0.0237	0.0004	265
EWR	13,087	1.1716	0.0222	13,119
George Washington Bridge	784	0.0702	0.0013	786
George Washington Bridge Bus Station	786	0.0704	0.0013	788

Table 2-6: 2014 GHG Emissions from Stationary Combustion by Facility (metric tons)				
Building/Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Goethals Bridge	484	0.0433	0.0008	485
Holland Tunnel	665	0.0595	0.0011	667
Howland Hook	58	0.0052	0.0001	59
JFK	13,451	1.2445	0.0285	13,486
LGA	5,145	0.5033	0.0147	5,160
Lincoln Tunnel	152	0.0136	0.0003	153
Outerbridge Crossing	93	0.0083	0.0002	93
PATC	1,050	0.0940	0.0018	1,052
PATH Buildings	2,903	0.2754	0.0071	2,911
PCNJ	310	0.0277	0.0005	310
Port Authority Bus Terminal	28	0.0025	0.0000	28
SWF	793	0.0710	0.0013	795
TEB	509	0.0455	0.0009	510
Teleport	126	0.0113	0.0002	127
Total	**41,500**	**3.8136**	**0.0842**	**41,606**

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

Table 2-7: 2014 CAP Emissions from Stationary Combustion by Department (metric tons)			
Department	**SO_2 (kg)**	**NO_x (kg)**	**PM (kg)**
Aviation	2.4499	27.8759	2.2622
Central Administration	0.0073	1.2124	0.0921
PATH	0.4429	2.4375	0.2122
Port Commerce	0.0032	0.5273	0.0401
Real Estate	0.0006	0.1053	0.0080
Tunnels, Bridges, and Bus Terminals	0.0152	2.5399	0.1930
Total	**2.9191**	**34.6983**	**2.8077**

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

Table 2-8: 2014 CAP Emissions from Stationary Combustion by Facility (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
225 PAS	0.0003	0.0554	0.0042
777 Jersey	0.0017	0.2825	0.0215
AirTrain JFK	0.0017	0.2904	0.0221
Bayonne Bridge	0.0003	0.0472	0.0036
Brooklyn Marine Terminal	0.0013	0.2206	0.0168
EWR	0.0654	10.9044	0.8287
George Washington Bridge	0.0039	0.6530	0.0496
George Washington Bridge Bus Station	0.0039	0.6553	0.0498
Goethals Bridge	0.0024	0.4029	0.0306
Holland Tunnel	0.0033	0.5542	0.0421
Howland Hook	0.0003	0.0486	0.0037
JFK	1.1756	11.2570	0.9253
LGA	1.2006	4.3391	0.4037
Lincoln Tunnel	0.0008	0.1269	0.0096
Outerbridge Crossing	0.0005	0.0773	0.0059

Table 2-8: 2014 CAP Emissions from Stationary Combustion by Facility (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
PATC	0.0052	0.8745	0.0665
PATH Buildings	0.4429	2.4375	0.2122
PCNJ	0.0015	0.2580	0.0196
Port Authority Bus Terminal	0.0001	0.0233	0.0018
SWF	0.0040	0.6610	0.0502
TEB	0.0025	0.4239	0.0322
Teleport	0.0006	0.1053	0.0080
Total	**2.9191**	**34.6983**	**2.8077**

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

2.2 EMERGENCY GENERATORS AND FIRE PUMPS

All facilities under Port Authority's operational 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. These methodologies are based on engineering estimates and are qualified as SEM for TCR reporting purposes.

2.2.2 Method

Table 2-9 provides the emission factors developed for emergency generators during this exercise.

Table 2-9: Emergency Generator and Fire Pump GHG and CAP Emission Factors		
Pollutant	**Emergency Generator (TPY/MWh)**	**Fire Pump (TPY/MWh)**
CO_2	1.28×10^{-3}	1.73×10^{-4}
CH_4	1.88×10^{-7}	2.57×10^{-8}
N_2O	1.03×10^{-8}	1.40×10^{-9}

Table 2-9: Emergency Generator and Fire Pump GHG and CAP Emission Factors		
Pollutant	**Emergency Generator (TPY/MWh)**	**Fire Pump (TPY/MWh)**
NO_x	3.47×10^{-5}	4.68×10^{-6}
SO_x	2.25×10^{-6}	3.08×10^{-7}
PM	2.42×10^{-6}	3.29×10^{-7}

2.2.3 Results

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

Table 2-10: 2014 GHG Emissions from Emergency Generators and Fire Pumps (metric tons)		
Pollutant	**Emergency Generators**	**Fire Pumps**
CO_2	609.2	59.5
CH_4	0.0894	0.0088
N_2O	0.0049	0.005
CO_2e	612.56	59.79

Total emergency generator CAP emission estimates are shown in Table 2-11.

Table 2-11: 2014 CAP Emissions from Emergency Generators (metric tons)		
Pollutant	**Emergency Generators**	**Fire Pumps**
NO_x	16.4740	1.6081
SO_x	1.0691	0.1057
PM	1.1481	0.1130

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,) was ascribed to calendar year 2014.

3.0 MOBILE COMBUSTION (SCOPE 1)

Mobile combustion emissions result from the combustion of fuels by on-road vehicles, non-road vehicles, and portable equipment that is owned and operated by the Port Authority. The Port Authority's Central Automotive Division (CAD) oversees the procurement and maintenance of on-road vehicles, most non-road vehicles, and some portable equipment. Additionally, PATH operates and services a small number of non-road vehicles and portable equipment.

3.1 CENTRAL AUTOMOTIVE DIVISION FLEET

CAD is in charge of purchasing and maintaining the Port Authority's fleet of vehicles. CAD relies on records either from fuel management system or from fuel vendor invoices—as in the case of compressed natural gas (CNG)—to track fleet fuel consumption. Additionally, CAD encourages on-road vehicle operators to log mileage information when filling up to better estimate methane, nitrous oxide and CAP emissions. The CAD fleet consumes conventional fuels like gasoline and diesel as well as alternative fuels such as compressed natural gas (CNG), gasoline with an 85 percent ethanol blend (E85), and diesel with a 20 percent biodiesel blend (B20). Table 3-1 summarizes CAD fleet fuel consumption by fuel type in 2014.

Table 3-1: 2014 CAD Fleet Fuel Consumption

Fuel	Consumption	Units
Gasoline (E10)	1,139,388	Gallons
#2 Diesel	20,975	Gallons
Biodiesel (B20)	311,624	Gallons
E85	93,172	Gallons
CNG	41,662	CCF
Propane	2,052	Gallons

3.1.1 Activity Data

For the purpose of the fuel tracking, the CAD fleet is divided between the main fleet and a subset of vehicles assigned to specific functions within the Port Authority as shown in Figure 3-1. The main fleet is composed of 2,297 vehicles, which includes on-road and non-road vehicles as well as portable equipment. CAD retains the services of Sprague, a fuel management contractor, to track the volume of fuel dispensed from a network of authorized fuel stations by means of dedicated fuel cards. For each fuel type, the volume of fuel dispensed was used to calculate CO_2 emissions from the main fleet. On the other hand, the Port Authority Office of the Treasury tracks fuel consumption for all the other CAD vehicles by means of branded fuel cards (e.g., Shell Fuel Card). 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. The Office of the Treasury maintains a financial record of fuel purchases, so in order to convert

expenditures to fuel volume, the 2014 annual average fuel price of $3.50 per gallon for the middle Atlantic region was applied (EIA 2015). This analysis also assumed that 99 percent of fuel consumption was gasoline and the remaining 0.1 percent was diesel based on the actual record for 2012, when information on fuel volume by fuel type was available.

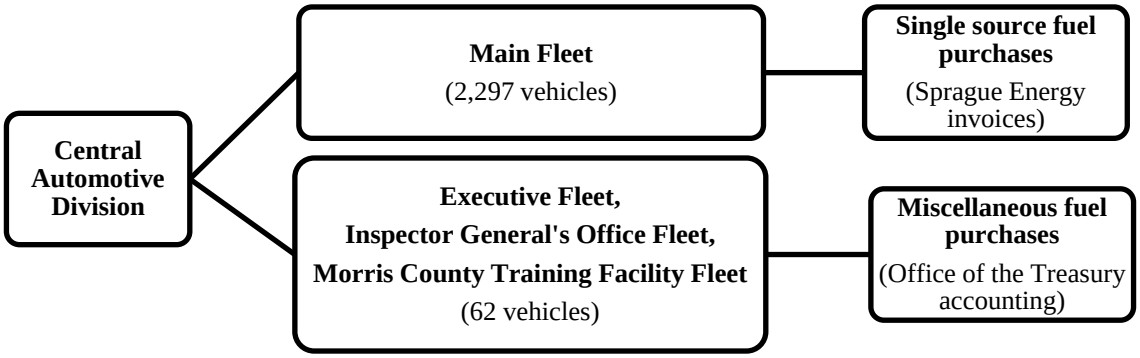

Figure 3-1: Recordkeeping for CAD Fleets

Activity data for estimating CAP emissions came from CAD in the form of vehicle activity. Vehicle activity came in different units of measurement according to 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)—fuel consumption served as the activity data. The selection of the best emission factor based on available activity data is discussed in Section 3.1.2 below for each fleet segment.

3.1.2 Method

GHG emission estimates were calculated as the product of fuel use and fuel-specific emission 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, attention was given to distinguishing between anthropogenic and biogenic emissions. This was accomplished by correlating the fossil fuel-specific emission factor to the volume of fossil fuel consumed. For example, for a volume of 100 gallons of E10, anthropogenic CO_2 emissions equal:

$$100 \text{ gallons of E10} \times 90 \text{ percent fossil fuel by volume} \times 8.78 \text{ kg } CO_2/\text{gal} = 790.2 \text{ kg } CO_2$$

Biogenic CO_2 emission estimates (i.e., those generated during the combustion or decomposition of biologically based material such as biodiesel or ethanol) are calculated by correlating the biofuel-specific emission factor to the volume of biofuel consumed. For example, for a volume of 100 gallons of E10, biogenic CO_2 emissions equal:

100 gallons of E10 × 10 percent ethanol by volume × 5.75 kg CO_2/gal = 57.5 75 kg CO_2

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	Fossil Fuel 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 emission 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 (E10) 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. Table 3-3 shows the effective CO_2 emission 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	Anthropogenic 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

CAP emission factors for highway vehicles are from the EPA Motor Vehicle Emissions Simulator (MOVES 2014) (EPA 2014a). These emission factors are expressed in units of grams per mile based on model year and vehicle type for the 2014 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. Flex Fueled vehicles were assumed to be burning E85. These emission factors were then multiplied by the 2014 estimates of mileage per vehicle provided by the CAD to obtain CAP emissions.

There were many cases in which highway 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.

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

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.

3.1.3 Results

Table 3-4 presents GHG emission estimates for CAD's main fleet by fuel type. Table 3-5 shows the emissions by fuel type from the executive fleet, security and training vehicles (i.e., Non-Main Fleet), tracked by the Office of the Treasury. Biogenic emissions from the main fleet, executive fleet, security and training vehicles totaled 1,718 tCO2e in 2014.

Table 3-4: 2014 GHG Emissions for Main Fleet Vehicles (metric tons)

Fuel Type	CO_2	Biogenic CO_2	CH_4	N_2O
Gasoline (E10)	9,003.4	655.1	6.0E-01	6.7E-01
#2 Diesel	214.2	0.0	1.3E-02	1.5E-02
Biodiesel (B20)	2,545.3	589.0	2.0E-01	2.2E-01
E85	122.7	455.4	3.6E-02	4.0E-02
CNG	225.0	0.0	1.4E-02	1.6E-02
Propane	11.5	0.0	7.1E-04	8.0E-04
Total	**12,122.1**	**1,699.5**	**8.6E-01**	**9.6E-01**

Table 3-5: 2014 GHG Emissions for Non-Main Fleet Vehicles (metric tons)

Department	CO_2	Biogenic CO_2	CH_4	N_2O
Gasoline (E10)	251.5	18.3	0.017	0.019
#2 Diesel	0.4	0	<0.001	<0.001
Total	**251.9**	**18.3**	**0.017**	**0.019**

Table 3-6 summarizes anthropogenic GHG emission for the entire CAD fleet by selected calculation methodology; note CO_2 emissions use a standard method, while the CH_4 and N_2O emissions use SEMs.

Table 3-6: 2014 GHG Emissions for the CAD Fleet by Method (metric tons)				
Emission Method	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Standard Method	12,122	0.0	0.0	12,122
SEM	252	0.9	1.0	575
Total	**12,374**	**1**	**1**	**12,697**

Table 3-7 shows the CAP emission estimates for the entire CAD fleet. Note that vehicles labeled "Zero Fuel Recorded" refers to a subset of highway and non-highway vehicles for which emissions were estimated based on mileage information.

Table 3-7: 2014 CAP Emissions for the CAD Fleet (metric tons)				
Vehicle Type	**NO_x**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**
Highway Vehicles	7.57	0.21	2.26	0.59
Non-highway Vehicles	0.24	0.00	0.03	0.02
Zero Fuel Recorded	1.67	0.01	0.19	0.10
Bulk CNG	0.04	0.01	0.04	0.04
Propane	0.03	0.00	0.00	0.00
Executive/Security Fleet	1.59	0.10	0.45	0.41
Total	**11.15**	**0.33**	**2.96**	**1.17**

3.2 PATH DIESEL EQUIPMENT

PATH owns and operates certain track maintenance vehicles that are not accounted for by the CAD. PATH equipment includes a small number of non-road vehicles and portable equipment. For the 2014 inventory, the emission estimates were carried over from the 2013 assessment and labeled as an SEM for TCR reporting purposes.

3.2.1 Activity Data

PATH non-road and portable equipment burns diesel fuel exclusively. Annual fuel consumption is tracked for each individual piece of equipment. This information serves as the activity data for GHG and CAP emission assessments.

3.2.2 Method

CO_2 emission estimates are calculated 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 emission estimates 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).

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

3.2.3 Results

Total GHG emissions for PATH diesel equipment are shown in Table 3-8. . For the 2014 inventory, the emission estimates were carried over from the 2013 assessment and labeled as a SEM for TCR reporting purposes

Table 3-8: 2014 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

Table 3-9 shows CAP emissions for PATH non-road vehicles and portable equipment.

Table 3-9: 2014 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 that are not the result of fossil fuel combustion. 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 biogas gas emanating from a closed landfill.

4.1 USE OF REFRIGERANTS

Emissions of HFCs and PFCs from stationary and mobile AC equipment result from the fugitive release over the operational life of the equipment. While common refrigerants, such as R-22, R-12, and R-11 [i.e., hydrochlorofluorocarbons (HCFCs) or chlorofluorocarbons (CFCs)], have a climate forcing effect, they are not required to be reported to TCR because production of HCFCs and CFCs is already being phased out under the Montreal Protocol.

The 2014 approach for estimating refrigerant fugitive emissions is consistent with 2013, which follows the decision tree shown in Figure 4-1. The 2014 inventory has taken a significant step forward in getting survey information wherever possible, and thus all emission estimates for 2014 were developed using method options 1 or 2 which yield results with lower uncertainty compared to previous inventories. A brief description of each of the method options follows.

<u>Option 1</u>

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.

<u>Option 2</u>

Refrigerant fugitive emission estimates using Option 2 rely on an AC equipment count and information about the type of refrigerant, typical annual utilization, the equipment's nameplate refrigerant charge, and equipment's application (e.g., chiller or residential/commercial AC, including heat pump). Rates of refrigerant release are then correlated to each AC equipment profile. The resulting emission estimates for each HFC and PFC are then converted to units of CO_2e using the appropriate GWP factors to determine total HFC and PFC emissions. This method is incorporated into the GRP as an approved SEM (TCR 2013a).

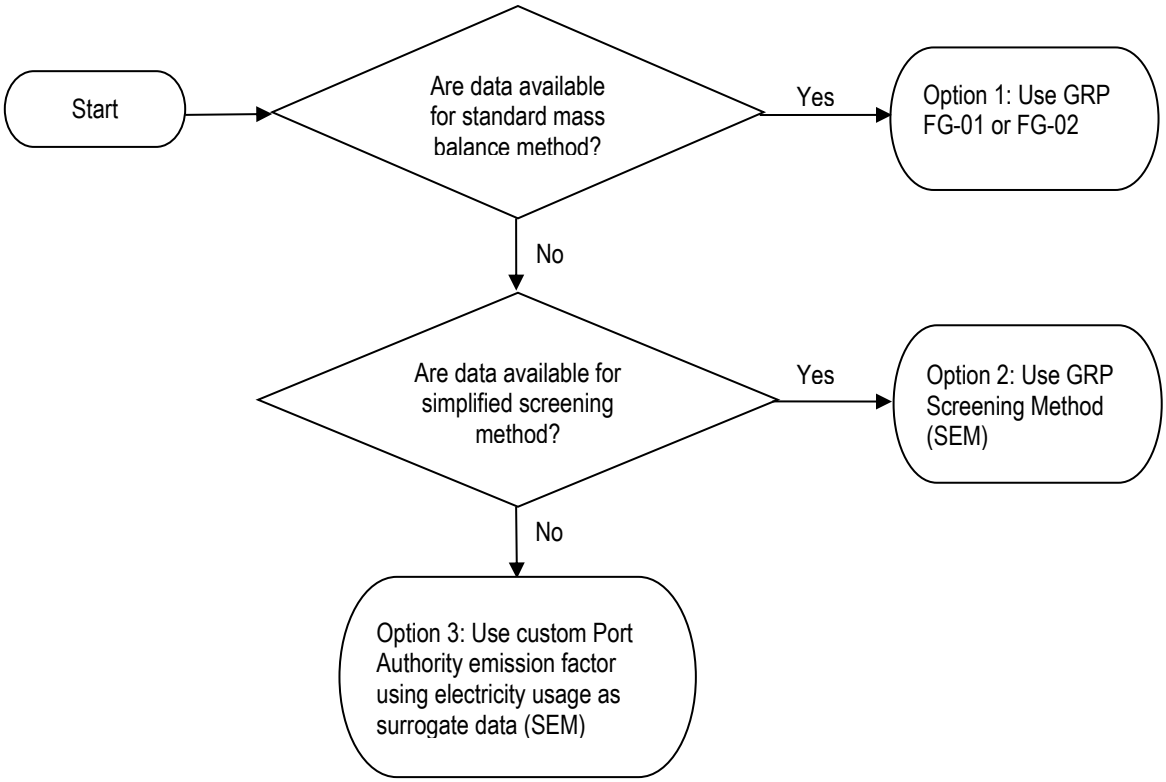

Figure 4-1: Selection of Method to Quantify Fugitive Emissions from AC Equipment

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. Emission estimates developed using this option are categorized as SEMs (TCR 2013a, p. 128).

Table 4-1 presents the method option selected for each facility based on best available activity data. This table highlights the improvements that were made in the survey responses and the activity data between 2013 and 2014.

GHG emission estimates for refrigerants used by the Port Authority during 2014 are shown in Table 4-2. This table excludes non-reportable HCFCs and CFCs, such as R-22. Shaded cells refer to facilities for which air conditioning systems were surveyed and found not to contain any GHGs. Total estimated emissions from refrigerants in 2014 went down significantly from the 2013 estimate. This is primarily due to receiving better AC equipment profiles from Port Authority facilities than in previous inventories. Better activity data were conducive to eliminating the use of method option 3, which was known to yield very conservative, upper-limit emission estimates.

Table 4-1: Selection of Refrigerant Methodology Option by Facility in 2013 and 2014			
Facility Description		**2013 Method**	**2014 Method**
Fleet (CAD)	CAD	Option 2	
JFK	JFK	Option 3	Option 2
LGA	LGA	Option 3	Option 2
SWF	SWF	Option 2	
EWR	EWR	Option 2	
TEB	TEB	Option 3	Option 2
Port Commerce Facilities NY	Brooklyn Cruise Terminal	Option 2	
	Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)	Option 2	
	Howland Hook Marine Terminal	Option 3	Option 2
Port Commerce Facilities NJ	Elizabeth Port Authority Marine Terminal	Option 3	Option 2
	Port Jersey	Option 3	Option 2
	Port Newark Marine Terminal	Option 3	Option 2
Tunnels & Bridges	George Washington Bridge	Option 2	
	Holland Tunnel	Option 2	
	Lincoln Tunnel	Option 2	
Bus Terminals NY	George Washington Bridge Bus Station	Option 3	Option 2
	PABT	Option 2	
AirTrain JFK	AirTrain JFK	Option 3	Option 2
AirTrain EWR	AirTrain EWR	Option 3	Option 2
PATH	PATH	Option 2	
PATH Buildings	PATH Buildings	Option 2	
	PATH Buildings (54 window units)	Option 3	Option 2

Table 4-2: 2014 Refrigerant Emissions by Facility and Reportable GHG (metric tons CO_2e)							
Facility Description	**HFC-134a**	**HFC-227ea**	**R-134A**	**R-404A**	**R-407C**	**R-410A**	**Total**
Central Automotive					258.6		258.6
JFK Airport							
LaGuardia Airport			6.7			0.6	7.3
Stewart Airport	2.3					1.7	4.1
Newark Airport	859.8	140.3					1,000.0
Teterboro Airport	0.1					3.9	4.0
Brooklyn Cruise Terminal							
Brooklyn Marine Terminal						2.4	2.4
Howland Hook/Port Ivory						2.4	2.4
Port Elizabeth Marine Terminal						1.5	1.5
Port Jersey			<0.1			1.8	1.8
Port Newark Marine Terminal	0.1			0.3		3.1	3.6
George Washington Bridge	0.1			0.9		2.1	3.1
Holland Tunnel	<0.1	<0.1					<0.1

Table 4-2: 2014 Refrigerant Emissions by Facility and Reportable GHG (metric tons CO_2e)							
Facility Description	**HFC-134a**	**HFC-227ea**	**R-134A**	**R-404A**	**R-407C**	**R-410A**	**Total**
Lincoln Tunnel	0.1						0.1
Staten Island Bridges							
GW Bridge Bus Station	<0.1			1.3		2.5	3.8
Port Authority Bus Terminal	1.4						1.4
AirTrain JFK						3.9	3.9
AirTrain Newark					22.9		22.9
PATH Trains					1,043.9		1,043.9
PATH Buildings	284.4						284.4
Bathgate Industrial Park							
The Teleport							
Total	**1,148.3**	**140.3**	**6.7**	**2.6**	**1,325.4**	**26.0**	**2,649.2**

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 common 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 4-3.

Table 4-3: 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	X	
Staten Island Bridges		X		
George Washington Bridge Bus Station				X
PABT			X	

Table 4-3: Fire Protection Equipment by Facility and Suppressant Type				
Facility Description	**Type of Fire Suppressant**			
	CO_2	**FM-200**	**No GHG**	**Unknown**
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 Port Authority indicated that in 2014 there were no fire suppressant releases from fire events, except for a negligible amount (approximately 0.1 metric tons of CO_2) 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 were used to estimate the CH_4 emissions from the landfill using the first-order decay model prescribed by TCR (TCR 2013a). A similar model, EPA's Landfill Gas Emissions Model (LandGEM) (EPA 2005), was used to estimate VOC emissions.

Because of a lack of waste emplacement records, the annual mass of waste received at the site was calculated as the product of the average refuse depth of 8.33 feet as measured 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.[1] 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 Method

Emissions estimates were developed in accordance with "Local Government Operations Protocol," Chapter 9, "Solid Waste Management," as prescribed by TCR (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 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 4-4, but they are classified as biogenic and not included in the CO_2e emissions total for the site.

4.3.3 Results

The 2014 GHG emission estimates for the historic Elizabeth Landfill are shown in Table 4-4. The GHG emission estimates are just for the landfill portion that is under the operational control of the Port Authority.

Table 4-4: 2014 GHG Emissions from the Historic Elizabeth Landfill

Biogenic CO_2 (metric tons)	CH_4 (metric tons)	CH_4 (metric tons CO_2e)
625	186	3,912

In addition to GHG emissions, the historic Elizabeth Landfill also emits VOCs, a precursor to CAPs. In 2014, the historic Elizabeth Landfill emitted 0.786 metric tons of VOCs.

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

5.0 PURCHASED ELECTRICITY (SCOPE 2)

The combustion of fossil fuels for the purpose of electricity generation will yield 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 5-2 summarizes electricity consumption of Port Authority operations by facility.

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 Bus Station	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	World Trade Center Tower 4	

Note: Facilities may include multiple buildings.

Table 5-2: Port Authority Facilities' Electricity Consumptions

Facility	Electricity Consumed (MWh)
115 Broadway	554.4
116 Nassau St	183.7
225 PAS	2,495.9
233 PAS	811.4
4 World Trade Center	3,256.8
777 Jersey	1,306.2
96 Broadway	700.8
AirTrain JFK	40,717.0
AirTrain Newark	18,890.3
Bathgate Industrial Park	75.2

Table 5-2: Port Authority Facilities' Electricity Consumptions	
Facility	**Electricity Consumed (MWh)**
Bayonne Bridge	629.1
Brooklyn Marine Terminal	490.1
EWR	89,678.8
Gateway Newark	1,136.9
George Washington Bridge	6,070.9
George Washington Bridge Bus Station	5,017.6
Goethals Bridge	2,536.6
Holland Tunnel	9,527.5
Howland Hook	395.5
JFK	76,176.0
LGA	41,333.4
Lincoln Tunnel	19,794.8
Outerbridge Crossing	1,439.9
PATC	15,417.3
PATH Buildings	17,061.5
PATH Rail System	96,222.9
PCNJ	19,283.6
Port Authority Bus Terminal	25,017.7
SWF	4,196.8
TEB	1,899.1
Teleport	5,428.5
Grand Total	**507,746.3**

5.1 BUILDINGS

This section 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.

5.1.1 Activity Data

The Port Authority provided data on electricity consumption by month for each facility 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 Method

The GHG emission factors used to estimate the GHGs associated with electricity consumption are shown in Table 5-3.

Table 5-3: 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)	0.316	1.16×10^{-5}	1.33×10^{-6}
NYUP (NPCC Upstate NY)	0.185	7.07×10^{-6}	1.74×10^{-6}
RFCE (RFC East)	0.389	1.20×10^{-5}	5.21×10^{-6}
KIAC Facility (Kennedy International Airport Cogeneration)	0.413	2.96×10^{-5}	7.00×10^{-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 "2015 Climate Registry Default Emission Factors" (TCR 2015), 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 2012a). Because more GHGs are associated with coal combustion than with natural gas combustion, the emission factors in the Reliable First Corporation East subregion are higher than those in NPCC – NYC/Westchester.

The electricity GHG and PM emission factors for KIAC were determined as described in Section 7.1. The resulting KIAC electricity emission factors are presented in Table 5-3 for GHGs and Table 5-4 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 2012a). Emission factors for PM were calculated in proportion to the SO_2 emissions based on values derived from the 2011 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:

$$Ef_{PM} = Ef_{SO_2} x \frac{\sum_{State} PM}{\sum_{State} SO_2} \tag{5-1}$$

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 5-4 shows the CAP emission factors used for the 2014 electricity emission estimates.

Table 5-4: 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	2.91×10^{-5}	1.51×10^{-4}	1.86×10^{-6}	2.74×10^{-6}
NPCC Upstate NY	2.95×10^{-4}	1.25×10^{-4}	1.81×10^{-5}	2.62×10^{-5}
Reliable First Corporation East	6.40×10^{-3}	3.62×10^{-4}	3.74×10^{-4}	3.82×10^{-4}
KIAC	1.10×10^{-6}	8.17×10^{-5}	2.63×10^{-5}	2.63×10^{-5}

5.1.3 Results

Emission 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 and 2013. In accordance with GRP guidelines, emissions developed from engineering calculations are reported separately as SEM for TCR reporting purposes.

Table 5-5 lists the GHG emission estimates for each department, excluding emissions associated with electricity consumption on the PATH, AirTrain JFK, and AirTrain EWR, which are presented in Table 5-9.

Table 5-5: 2014 GHG Emissions from Electricity Consumptionin Buildings by Department (metric tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	80,963	3.8610	1.0727	81,377

Table 5-5: 2014 GHG Emissions from Electricity Consumptionin Buildings by Department (metric tons)				
Department	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
PATH	6,644	0.2046	0.0889	6,676
Tunnels, Bridges, and Bus Terminals	23,836	0.8202	0.1832	23,910
Central Administration	8,455	0.2691	0.0994	8,492
Port Commerce	7,790	0.2415	0.1017	7,826
Real Estate	2,768	0.1014	0.0116	2,774
Total	**130,457**	**5.4978**	**1.5576**	**131,055**

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.

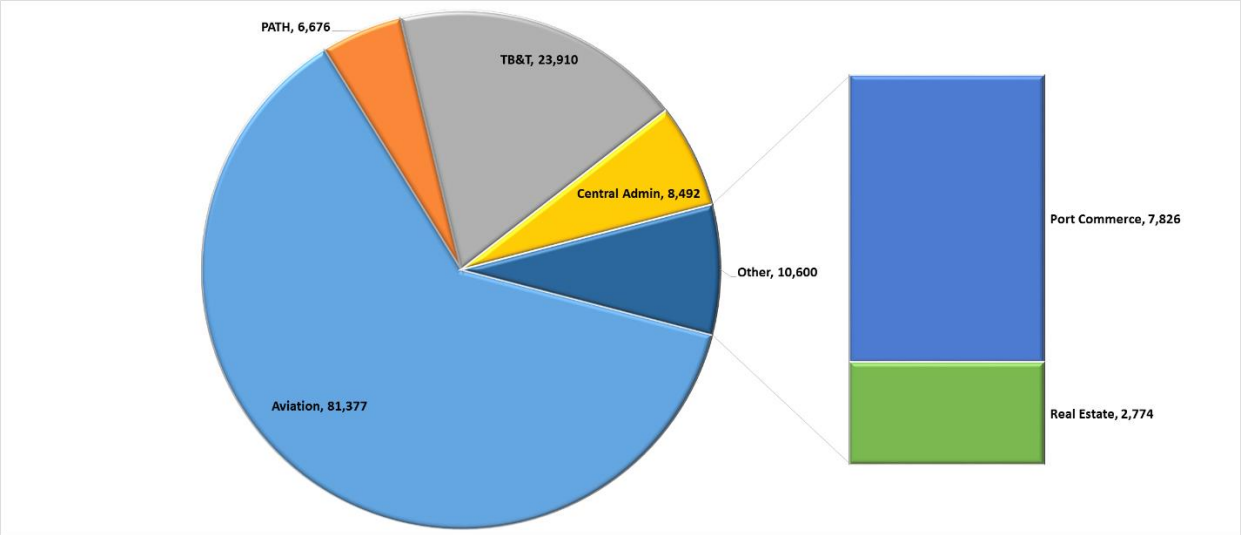

Figure 5-1: 2014 CO2e Emissions from Electricity Consumption by Department

Table 5-6 shows the emission 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 5-6: 2014 GHG Emissions from Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
EWR	34,924	1.0755	0.4674	35,092
JFK	31,459	2.2548	0.5332	31,672
LGA	13,062	0.4783	0.0549	13,089
Port Authority Bus Terminal	7,906	0.2895	0.0332	7,922
PCNJ	7,510	0.2313	0.1005	7,546
Lincoln Tunnel	7,101	0.2339	0.0710	7,128
PATH Buildings	6,644	0.2046	0.0889	6,676
PATC	6,004	0.1849	0.0804	6,033

Table 5-6: 2014 GHG Emissions from Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Holland Tunnel	3,363	0.1123	0.0313	3,375
George Washington Bridge	2,364	0.0728	0.0316	2,376
George Washington Bridge Bus Station	1,954	0.0602	0.0262	1,963
Teleport	1,716	0.0628	0.0072	1,719
4 World Trade Center	1,029	0.0377	0.0043	1,031
Goethals Bridge	846	0.0296	0.0057	848
225 PAS	789	0.0289	0.0033	790
SWF	778	0.0297	0.0073	781
TEB	740	0.0228	0.0099	743
777 Jersey	509	0.0157	0.0068	511
Outerbridge Crossing	471	0.0168	0.0028	472
Gateway Newark	443	0.0136	0.0059	445
233 PAS	256	0.0094	0.0011	257
96 Broadway	221	0.0081	0.0009	222
Bayonne Bridge	200	0.0073	0.0009	200
115 Broadway	175	0.0064	0.0007	176
Brooklyn Marine Terminal	155	0.0057	0.0007	155
Howland Hook	125	0.0046	0.0005	125
116 Nassau St	58	0.0021	0.0002	58
Bathgate Industrial Park	24	0.0009	0.0001	24
Total	**130,457**	**5.4978**	**1.5576**	**131,055**

CAP emission totals are presented by department and by facility in Table 5-7 and Table 5-8, respectively.

Table 5-7: 2014 CAP Emissions for Electricity Consumption by Department (metric tons)				
Department	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Aviation	74.503	56.663	44.430	45.421
PATH	10.916	5.008	5.583	8.490
Tunnels, Bridges, and Bus Terminals	16.216	15.481	8.773	9.006
Port Commerce	12.353	7.054	7.215	7.375
Central Administration	11.567	7.182	6.691	6.843
Real Estate	0.255	1.324	0.017	0.024
Total	**125.821**	**92.773**	**72.710**	**77.159**

Table 5-8: 2014 CAP Emissions for Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
EWR	57.384	33.549	34.293	32.461
PCNJ	12.339	7.214	7.374	6.980
PATH Buildings	10.916	6.382	6.523	6.175
PATC	9.865	5.768	5.896	5.581
Lincoln Tunnel	7.611	4.325	4.427	5.420
George Washington Bridge	3.885	2.271	2.321	2.197
George Washington Bridge Terminal	3.211	1.877	1.919	1.816

Table 5-8: 2014 CAP Emissions for Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Holland Tunnel	3.205	1.802	1.846	2.451
SWF	1.237	0.076	0.110	0.525
TEB	1.215	0.710	0.726	0.687
LGA	1.202	0.078	0.113	6.249
JFK	0.838	2.003	2.003	6.224
777 Jersey	0.836	0.489	0.500	0.473
Gateway Newark	0.727	0.425	0.435	0.412
Port Authority Bus Terminal	0.727	0.047	0.069	3.782
Goethals Bridge	0.441	0.229	0.235	0.510
Outerbridge Crossing	0.175	0.084	0.087	0.264
Teleport	0.158	0.010	0.015	0.821
4 World Trade Center	0.095	0.006	0.009	0.492
225 PAS	0.073	0.005	0.007	0.377
Bayonne Bridge	0.026	0.006	0.007	0.098
233 PAS	0.024	0.002	0.002	0.123
96 Broadway	0.020	0.001	0.002	0.106
115 Broadway	0.016	0.001	0.002	0.084
Brooklyn Marine Terminal	0.014	0.001	0.001	0.074
Howland Hook	0.012	0.060	0.001	0.001
116 Nassau St	0.005	0.000	0.001	0.028
Bathgate Industrial Park	0.002	0.000	0.000	0.011
Total	**113.194**	**83.423**	**65.494**	**67.018**

5.2 RAIL SYSTEMS

The three separate train systems under the jurisdiction of the Port Authority are 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 Method

As described in Section 5.1.3, emission 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 5-3. 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 Results

GHG emission estimates were developed from records of electricity consumption (i.e., utility statements). Table 5-9 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 5-3). CAP emission estimates from electricity consumption for the train systems are given in Table 5-10.

Table 5-9: 2014 GHG Emissions from Electricity Consumption by Train System (metric tons)

Train	CO_2	CH_4	N_2O	CO_2e
PATH Rail System	37,473	1.1540	0.5015	37,652
AirTrain JFK	16,323	1.1137	0.2562	16,426
AirTrain Newark	7,357	0.2266	0.0985	7,392
Total	**61,152**	**2.4942**	**0.8562**	**61,470**

Table 5-10: 2014 CAP Emissions from Electricity Consumption by Train System (metric tons)

Train	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PATH Rail System	61.57	34.83	36.00	36.80
AirTrain Newark	12.09	6.84	7.07	7.22
AirTrain JFK	0.54	3.68	0.95	0.95
Total	**74.20**	**45.35**	**44.01**	**44.97**

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

This chapter discusses emissions associated with energy purchases or acquisitions 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 AND 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 TCR'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 emission 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 Method

The heating and cooling GHG and PM emission factors for KIAC were determined as described in Section 7.1.. The resulting heating and cooling emission factors are presented in Table 6-1 for GHGs and Table 6-2 for CAPs.

Table 6-1: 2014 KIAC GHG Emission Factors

Product	CO_2	CH_4	N_2O
Heating (kg/MMBtu)	62.29	4.50×10^{-3}	1.10×10^{-3}
Cooling (kg/MMBtu)	62.29	4.50×10^{-3}	1.10×10^{-3}

Table 6-2: 2014 KIAC CAP Emission Factors

Product	SO_2	NO_x	$PM_{2.5}$	PM_{10}
Heating (kg/MMBtu)	1.70×10^{-4}	1.23×10^{-2}	4.00×10^{-3}	4.00×10^{-3}
Cooling (kg/MMBtu)	1.70×10^{-4}	1.23×10^{-2}	4.00×10^{-3}	4.00×10^{-3}

6.1.3 Results

Table 6-3 provides GHG emission estimates for the heating and cooling purchased from KIAC by the Port Authority

to service JFK and AirTrain JFK. Table 6-4 presents CAP emission estimates.

Table 6-3: 2014 GHG Emissions from KIAC Energy Purchases (metric tons)				
Energy Use	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
JFK Heating	2708.27	0.20	0.05	2727.20
JFK Cooling	5352.90	0.39	0.09	5390.33
JFK Total	**8061.17**	**0.58**	**0.14**	**8117.53**
AirTrain Heating	776.83	0.06	0.01	782.27
AirTrain Cooling	699.50	0.05	0.01	704.39
AirTrain Total	**1476.34**	**0.11**	**0.03**	**1486.66**

Table 6-4: 2014 CAP Emissions from KIAC Energy Purchases (metric tons)				
Energy Use	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK Heating	0.0739	0.5348	0.1739	0.1739
JFK Cooling	0.1461	1.0570	0.3437	0.3437
JFK Total	**0.2200**	**1.5918**	**0.5177**	**0.5177**
AirTrain Heating	0.0212	0.1534	0.0499	0.0499
AirTrain Cooling	0.0191	0.1381	0.0449	0.0449
AirTrain Total	**0.0403**	**0.2915**	**0.0948**	**0.0948**

6.2 PORT AUTHORITY BUS TERMINAL

The PABT reported steam usage for heating in 2014. 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 Method

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 Results

Because the GHG emission 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 snwo melting system for the Bus Terminal's ramp. During the testing, the Sovaloid System had to be operated at 150 degrees to ensure proper oil flow and to simulate system operation during a storm. CAP emission totals of purchased steam for PABT are given in Table 6-7.

Table 6-6: 2014 PABT GHG Emissions from Con Edison Steam Purchases (metric tons)				
Building	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
PABT	4,619	0.5213	0.0217	4,637

Table 6-7: 2014 PABT CAP Emissions from Con Edison Steam Purchases (metric tons)				
Building	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
PABT	2.6419	4.3459	0.4669	0.4669

7.0 ENERGY PRODUCTION (SCOPE 3)

This chapter discusses the emitting activities associated with two power generation plants owned by the Port Authority; namely, the Kennedy International Airport Cogeneration (KIAC) facility located in Queens County, New York, and the Essex County Resource Recovery (ECRR) facility located in Essex County, 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 needs of the JFK airport in which excess electricity is sold to 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 end users, including the Port Authority, JFK airport tenant, and downstream consumers of KIAC electricity.

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 2015).

7.1.2 Method

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 Electricity and Thermal Emission Factors

KIAC supplies electricity and thermal (heating and cooling) energy for the benefit of Port Authority operations and tenants. Best carbon accounting practices require that emissions from a combined heat and power (CHP) plant be allocated to end-users by means of electricity, heating, and cooling-specific emission factors. These emission factors were calculated first by allocating plant emissions in accordance with the specification of TCR (see Figure 7-1) to each useful energy output of the KIAC plant, and then dividing allocated emissions by the corresponding amount of useful energy. The resulting emission factors are presented in Table 7-2 for each useful energy output, namely electricity, heating, and cooling. These plant emission factors were used to estimate Port Authority indirect emissions from electricity and thermal energy consumption from KIAC, as described in sections 5.1.2 and 6.1.2, respectively.

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

Table 7-2: 2014 KIAC Electricity and Thermal Emission Factors by Pollutant							
Useful Energy Type	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
Heating (kg Pollutant/MMBtu	62.29	0.0045	0.0011	0.0123	0.0017	0.0040	0.0040
Cooling (kg Pollutant/MMBtu	62.29	0.0045	0.0011	0.0123	0.0017	0.0040	0.0040
Electricity (kg Pollutant/MWh)	412.98	0.0296	0.0070	0.0817	0.0110	0.0263	0.0263

7.1.4 Results

KIAC facility GHG emissions are presented in Table 7-3, and CAP emissions are summarized in Table 7-4. KIAC production emissions distributed by energy stream and end-user are presented in Table 7-5.

Table 7-3: 2014 KIAC Production GHG Emissions Summary (metric tons)			
CO_2	CH_4	N_2O	CO_2e
338,209	24.24	5.74	340,498

Table 7-4: 2014 KIAC CAP Emissions Summary (metric tons)			
NO_x	SO_2	$PM_{2.5}$	PM_{10}
66.93	9.00	21.56	21.56

Table 7-5: 2014 KIAC GHG and CAP Emissions Summary by End-User (metric tons)		
End-User	**Emission Category**	**CO_2e**
Port Authority	Purchased Electricity	46,488
	Purchased Cooling	6,095
	Purchased Heating	3,509
Tenants	Purchased Electricity	109,816
	Purchased Cooling	11,452
	Purchased Heating	9,329
Customers	Energy Production (electricity sold to market)	153,810
Total		**340,498**

7.2 ESSEX COUNTY RESOURCE RECOVERY FACILITY

At the ECRR facility, GHG and CAP emissions result from energy recovery activities, including the combustion of MSW as the primary source of energy for electricity generation, and diesel fuel combustion as an auxiliary energy source. This emitting activity includes emissions from electricity generation 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 Method

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 2015a), for the "Covanta Essex Company" profile. 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 EPA and meet the highest standard of accuracy under the GGRP. 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 2015a).

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 emission factors published by eGRID (EPA 2015b). The eGRID database provides emission 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.

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 2014b), 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 941,071 short tons. MSW tonnage was then multiplied by the corresponding PM emission factors. Table 7-6 presents the emission factors for CAPs.

Table 7-6: CAP Emission Factors for MSW Combustion

Pollutant	Value	Units	Source
NO_x	0.13	lb/MMBtu	EPA 2015b
SO_2	0.67	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 the TCR emission factor of 0.0014 kg of CH_4 per gallon of diesel fuel (TCR 2013b) results in an estimate that just over 85,000 gallons of distillate No. 2 fuel oil were combusted in 2014. These estimated gallons of diesel fuel were multiplied by the CAP emission factors for No. 2 fuel oil (see Table 7-7) obtained from EPA AP-42, Chapter 1, Table 1.3-1 (EPA 2010b).

Table 7-7: 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.

7.2.2 Results

Anthropogenic GHG emission from the ECRR facility are presented in Table 7-8. 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 0.3 percent resulting from No. 2 fuel oil combustion. The ECCR facility also had 502,447 tCO2e of biogenic emissions associated with the combustion of the organic materials, that largest component in MSW. CAP emission estimates are summarized in Table 7-9.

Table 7-8: 2014 Essex County Resource Recovery Facility GHG Emissions (metric tons)				
Fuel Type	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
MSW	341,132	285.97	37.53	358,772
Distillate No. 2 Fuel Oil	870	0.12	0.03	880
Total	**342,002**	**286.09**	**37.56**	**359,652**

Table 7-9: 2014 Essex County Resource Recovery Facility CAP Emissions (metric tons)				
Source	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
MSW Combustion	514	2,562	43	43
No. 2 Fuel Oil Combustion	1	5	0	0
Total	**515**	**2,567**	**43**	**43**

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

The 2014 anthropogenic CO_2e emissions due to combustion of MSW and fuel usage were 360,346 metric tons. This nets a 23 percent decrease in anthropogenic emissions from the facility during the 2006–2014 period. It is important to underscore that the introduction of EPA's GGRP has had the result of improving the quality of the GHG estimates since 2013, because it requires that GHG assessments be accurate to within a 5 percent margin of error. Table 7-10 summarizes emissions from assessments performed since 2006.

Table 7-10: GHG Emissions for Essex County Resource Recovery Facility, 2006–2014					
Essex County Resource Recovery Facility	**CO_2 Equivalent (metric tons)**				**Percentage Difference (2006 vs. 2014)**
	2006	**2008**	**2013**	**2014**	
Waste combusted	466,379	478,970	346,243	358,772	-23.1%
Diesel fuel combusted	2,148	1,826	1,247	880	-59.0%
Total	**468,527**	**480,796**	**347,490**	**359,652**	**-23.1%**

8.0 AIRCRAFT (SCOPE 3)

The Port Authority manages and operates the following airports:

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

While the Port Authority maintains financial control over the airport's infrastructure, it does not have operational control over aircraft or ground support equipment (GSE) operations. For that reason, greenhouse emissions reflected in this chapter correspond to tenant emissions (i.e., scope 3 emissions) over which the Port Authority has no operational control.

8.1 AIRCRAFT MOVEMENTS AND AUXILIARY POWER UNITS

For aircraft emissions, the inventory boundary encompasses aircraft operations that the Federal Aviation Administration (FAA) defines as itinerant and local. Itinerant operations are operations performed by an aircraft that lands at the airport, arriving from outside the airport area, or departs from the airport leaving the airport area. Local operations are those operations performed by aircraft that remain in the local traffic pattern, execute simulated instrument approaches or low passes at the airport, and the operations to or from the airport and a designated practice area within a 20-mile radius of the tower (FAA 2012). Additionally, the inventory boundary includes aircraft emissions associated with the following six times-in-mode (TIM). Combined, these six TIM constitute a Landing and Take-Off (LTO) cycle.

1. Approach – portion of the flight from the time that the aircraft reaches the mixing height (approximately 3,000 feet altitude) to touchdown on the runway.
2. Taxi In – the landing ground roll segment from touchdown to the runway exit of an arriving aircraft and the taxiing from the runway exit to a gate.
3. Startup – aircraft main engine startup emissions quantified for aircraft with ICAO certified engines.
4. Taxi Out – the taxiing from the gate to a runway end.
5. Takeoff – the portion from the start of the ground roll on the runway, through wheels off, and the airborne portion of the ascent up to cutback during which the aircraft operates at maximum thrust.
6. Climb out – the portion from engine cutback to the mixing height.

This chapter also covers emissions from the use of auxiliary power units APUs. These are on-board generators that provide electrical power to the aircraft while its engines are shut down. Excluded from this chapter are aircraft cruising emissions (i.e., emissions generated above mixing height between departure and arrival airports) because the study focuses on local emissions.

8.1.1 Activity Data

The primary modeling tool for analysis was the Federal Aviation Administration's (FAA's), Aviation Environmental Design Tool (AEDT), version 2b sp2, released December 2015. This model has replaced FAA's Emission and Dispersion Modeling System (EDMS) model, which was used on all previous Port Authority aviation inventories.

LTO data were provided for the five airports by the Aviation department (Port Authority 2015b). As a quality assurance/quality control (QA/QC) measure, total operations for each airport were normalized using airport operations data as reported in the FAA Air Traffic Activity Data System (ATADS). For example, at EWR airport, the Aviation department recorded 399,732 landing or takeoff operations in 2014. However, the ATADS database shows 402,281 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. Adjusted operations are shown in Table 8-1 below.

Table 8-1: 2014 Port Authority Operations by Airport

Airport	FAA ATADS Operations
JFK	431,236
EWR	402,281
LGA	370,012
SWF	39,459
TEB	167,119

8.1.2 Method

The AEDT model estimates emissions as a function of the volume of operations (i.e., annual number of arrivals and departures) by aircraft type and aircraft engine, as well as performance parameters – including the duration of each mode of operation (e.g., Taxi In; Taxi Out). Because aircraft operation data available from the Port Authority did not specify the type of engine associated with recorded aircraft types, the default aircraft engine was assigned to the aircraft type.

A crosswalk was used to correlate aircraft types between the International Civil Aviation Organization (ICAO) aircraft codes to the AEDT aircraft codes. Operations that were not directly correlated were distributed proportionately across the aircraft mix in order to match the ATADS total. In all five airports, more than 96% of all aircraft operations had a matching AEDT aircraft code. In general, this is higher at the three larger airports (greater than 99% match for EWR,

LGA and JFK), whereas the match was slightly lower for TEB (97%) and SWF (96%).

This analysis also included airport-specific taxi times to generate CO_2 and CAP emission estimates within the AEDT model. Airport-specific taxi times were provided by the Aviation department, and are displayed in Table 8-2 below. For EWR and LGA, these taxi times only include domestic operations by major (non-regional) domestic carriers. For JFK, Aerobahn data was used, which incorporates both domestic and international operations.

Table 8-2: 2014 Average Taxi In and Taxi Out Times by Airport (minutes)

Airport	Taxi In	Taxi Out
JFK	11:50	21:43
EWR	9:49	17:23
LGA	15:28	18:46
SWF	AEDT Default	
TEB	AEDT Default	

AEDT estimates emissions for VOC, CO, NO_x, SO_x, PM_{10}, and $PM_{2.5}$. AEDT also generates CO_2 emission estimates. Because this study is also interested in CH_4 and N_2O emissions, these pollutant estimates were prepared using the Tier I methodology found in the 2006 IPCC Guidelines for National Greenhouse Gas Emissions Inventories. The Tier I methodology estimates CH_4 and N_2O emissions as a function of LTO. IPCC emission factors were correlated to the fleet mix by means of the ICAO designators. Because the IPCC emission factors list is incomplete, there were instances where a match could be not established. Instead, a default CH_4 and N_2O emission factor was assigned – which was calculated as the average of attributes for matching aircraft types. The average aircraft CH_4 and N_2O emission factors are presented in Table 8-3. In general, the smaller aircraft at SWF and TEB have higher CH_4 emissions because they have less efficient engines, which results in more methane emissions.

Table 8-3: 2014 Average Aircraft CH_4 and N_2O Emission Factors (kg/LTO)

Airport	CH_4	N_2O
JFK	0.103	0.131
EWR	0.087	0.101
LGA	0.077	0.099
SWF	0.318	0.033
TEB	0.153	0.081

Auxiliary Power Units (APUs) are most often on-board generators that provide electrical power to the aircraft while its engines are shut down. The on-board APU is, in effect, a small jet engine and the calculations for the emissions generated by it are similar to that of an aircraft engine operating in one power setting only. For a given aircraft, APU emissions are modeled as the product of operations (i.e., arrivals/departure or LTOs), operating time, and engine emission factors. APU CAP emissions were modeled in AEDT as a function of operations and default APU assignation to aircraft categories. GHG emissions for APUs are not included in AEDT, and therefore were estimated 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), 2014 APU estimates were revised downward in cases where preconditioned air (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 8-4.

Table 8-4: Methodology to Determine Default APU Run Time

Gate Type	APU Run Time Determination Methodology
Gates without power and/or gates without PCA	No emission reduction; therefore, use AEDT 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).

The percentage availability of PCA and gate electrification at each airport was provided by the Port Authority, and is displayed in Table 8-5 below. In cases where both gate power and PCA are less than 100%, the lower of the two figures is used for calculations (for example, JFK is assumed to have 92% of gates with both gate power and PCA).

Table 8-5: Gate Electrification and PCA Available at Port Authority Airports, 2014

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%

8.1.3 Results

The methodology to estimate GHG and CAP emissions has taken a significant step forward with the use of the AEDT model, rather than EDMS. This latest model contains updated emission factors and methodology for estimating aircraft emissions, and therefore provides a higher quality estimate compared to those in EDMS.

GHG emission estimates from aviation sources are summarized by airport in Table 8-6 below. JFK accounts for the largest share of emissions, and also has the largest aircraft of the five airports. CO_2 emissions account for more than 98% of total CO_2e emissions from aircraft. In general, AEDT aircraft emission outputs were consistent with EDMS aircraft emissions outputs. The one exception is SWF, where CO_2 emissions dropped by 32% after accounting for a 14% decline in the volume of operations relative to Emission Year (EY) 2013. The remaining decline is due to changes in the SWF aircraft mix.

Table 8-6: 2014 Aircraft GHG Emissions by Airport (metric tons)					
Airport	**CO_2e**	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
JFK	767,457	758,226	0	22	28
EWR	417,651	410,977	0	17	20
LGA	365,474	359,517	0	14	18
SWF	17,995	17,434	0	3	2
TEB	56,436	55,019	0	27	3
Total	**1,625,013**	**1,601,173**	**0**	**83**	**71**

Table 8-7 shows the aircraft CAP emissions, as estimated within the AEDT model.

Table 8-7: 2014 Aircraft CAP Emissions by Airport (metric tons)				
Airport	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK	311	2,815	49	49
EWR	168	1,351	27	27
LGA	147	930	22	22
SWF	7	53	1	1
TEB	23	144	2	2
Total	**656**	**5,293**	**102**	**102**

APU GHG and CAP emissions are displayed in Table 8-8 and Table 8-9 respectively. These results reflect the effects of PCA and gate electrification where installed, which decrease the demand of running APU and lower emissions compared to a scenario without supplied PCA and gate electrification.

Table 8-8: 2014 APU GHG Emissions by Airport (metric tons)					
Airport	**CO_2e**	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
JFK	9,060	8,951	0	0	0
EWR	8,568	8,431	0	0	0
LGA	11,737	11,546	0	0	1
SWF	258	250	0	0	0
TEB	2,297	2,239	0	1	0
Total	**31,920**	**31,417**	**0**	**2**	**1**

Table 8-9: 2014 APU CAP Emissions by Airport (metric tons)				
Airport	**SO_2**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**
JFK	4	30	4	4
EWR	3	26	3	3
LGA	5	29	5	5
SWF	0	1	0	0
TEB	1	6	1	1
Total	**13**	**91**	**12**	**12**

8.2 GROUND SUPPORT EQUIPMENT

8.2.1 Activity Data

GSE equipment inventories were provided by the Port Authority (Port Authority 2015b) for the three larger airports namely JFK, EWR, and LGA. These inventories are based on airlines response to GSE surveys for equipment they operate, and served as the primary input for GSE emissions modeling for the larger airports. The inventories provide information about the make-up of the GSE fleet, most notably, number of units by equipment type (e.g., 6 counts of a Diesel – TUG MA 50 Tractor). Additionally, a crosswalk was developed to establish a direct correspondence between equipment types as reported by airlines and the equivalent equipment type from the GSE menu in AEDT.

Because GSE inventorying efforts have not yet been conducted at TEB and SWF, their GSE equipment counts were developed using EDMS default GSE assignments, which correspond to each airport's unique aircraft mix. In general, EDMS assigns a greater number of GSEs and utilization values (i.e., minutes per operation) to large and medium size aircrafts than to regional or business jets. Note that EDMS default GSE assignments were used at TEB and SWF because the current version of AEDT does not have an equivalent function.

8.2.2 Method

GSE CAP emissions were modeled in AEDT using the activity data described in Section 8.2.1. The GSE module in AEDT is a variation of EPA's NONROAD2008 model, which estimates GSE emissions as a function of equipment type (e.g., aircraft tractor, belt loader), utilization (i.e., hours per year), fuel type (e.g., diesel or gasoline), engine capacity, average load, and emission rates. In addition, a deterioration factor is applied based on the EPA-derived national fleet average age for a given equipment type.

AEDT generates estimates of criteria pollutants associated with GSE, but does not provide estimates of CO_2, CH_4 or N_2O. For that reason, GHG emissions were determined based on the quantitative relationship (i.e., stoichiometry) between SO_2 emissions and CO_2 emissions. This relationship was used because both SO_2 and CO_2 emissions are directly proportional to the mass of fuel combusted. That is, for any given concentration of sulfur, the CO_2/SO_2 ratio is constant. Then, CH_4/CO_2 and N_2O/CO_2 ratios—derived from standard fuel based emission factors (TCR 2015)— were applied to CO_2 emissions to determine CH_4 and N_2O emissions

8.2.3 Results

Table 8-10 shows the GHG emission estimates from GSEs by airport. The GSE module in AEDT2b fixed a bug in EDMS, which failed to properly link the default utilization value to a number of GSE equipment. This bug had the

consequence of underestimating GSE cumulative running hours in EY2013 for JFK, LGA, and EWR. Therefore, the EY2014 emission estimates represent an improvement over previous assessments performed in EDMS.

AEDT's default GSE age distribution leans "younger" with better emission performance than the default age distribution in EDMS. The implication is that EY2014 GSE emissions are significant lower than in EY2013 for the smaller airports (SWF and TEB).

Table 8-10: 2014 GSE GHG Emissions by Airport (metric tons)

Airport	CO_2e	CO_2	Biogenic CO_2	CH_4	N_2O
JFK	65,255	64,660	0	4	2
EWR	73,799	73,107	0	4	2
LGA	34,837	34,532	0	2	1
SWF	426	422	0	0	0
TEB	259	257	0	0	0
Total	**174,576**	**172,978**	**0**	**10**	**4**

Table 8-11 shows the CAP emission estimates from GSEs by airport.

Table 8-11: 2014 GSE CAP Emissions by Airport (metric tons)

Airport	SO_2	NO_x	$PM_{2.5}$	PM_{10}
JFK	1	414	24	25
EWR	1	349	15	16
LGA	0	167	10	10
SWF	0	2	0	0
TEB	0	1	0	0
Total	**3**	**933**	**49**	**51**

9.0 ATTRACTED TRAVEL (SCOPE 3)

9.1 AIRPORT PASSENGERS

For attracted travel related to airports (excluding cargo-related vehicles), the established boundary includes the trip to or from the airport up to a maximum of 100 miles. This boundary was developed based on the trip origin data received from the Port Authority's Aviation department (Port Authority 2015b). The airport passengers portion includes emissions associated with all vehicle trips that are attracted by airport facilities. Vehicle types (also referred to as travel mode) include privately-owned vehicles, taxis, buses, rental cars, limousines, vans, shuttle buses, public buses, and off-airport parking. Vehicle miles traveled (VMTs) for the airport facilities were calculated by mode and for the trip to or from the airport.

9.1.1 Activity Data

The data inputs to the attracted travel analysis were the 2014 passenger survey data (Port Authority 2015b), which provided the passenger origin/destination information, the 2014 total passenger data (Port Authority 2015c) for information on the total number of passengers, 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; Port Authority, 2016b).

The 2014 total passenger data was adjusted down to exclude in-transit passengers (passengers with a connection in a Port Authority airport prior to their destination), because these passengers do not induce attracted travel. The percentage of connecting flights by airport used to adjust total passenger volumes is presented in Table 9-1.

Table 9-1: Percentage of Total Passengers on Connecting Flights, 2014

Airport	Percent of Passengers
JFK	32%
EWR	33%
LGA	15%
SWF	2%
TEB	0%

Passengers are assumed to take a one-way trip (either to or from the airport) to their destination. In the case of passengers who are arriving/departing via personal car, it was assumed that this is a pickup/drop off, and therefore the round-trip distance is used to represent the attracted travel of each of these trips.

9.1.2 Method

For each airport, except TEB, the number of passengers was allocated by travel mode and trip origin to obtain the number of vehicles. The number of vehicles by travel mode and trip origin was estimated using number of passengers, trip distributions by travel mode to each passenger origin, average travel party size, and estimated distance traveled. Trip distributions by mode to each passenger origin were obtained from the Port Authority's Aviation department (Port Authority 2015b). Information on distance traveled and average travel party size are listed in **Error! Reference source not found.** and Table 9-3, respectively.

Error! Reference source not found. lists the trip origins for airport attracted travel with the corresponding estimated one-way travel distances by airport, except for TEB. Trip origin and travel mode data were not available for TEB. The methodologies used to estimate attracted travel emissions for TEB are discussed in a separate section later in this chapter. Distances reported in **Error! Reference source not found.** were estimated using Google Maps roadway trip lengths. The surrogate location associated with each origin/destination represents the most populous locality within the county or jurisdiction.

Table 9-2: One-Way Travel Distances Associated with Airport Facilities

Origin/Destination		Miles to/from[b]			
County/Jurisdiction	**Surrogate Location**	**JFK**	**LGA**	**EWR**	**SWF**
New York City					
Bronx	Bronx	17	10	27	
Brooklyn	Brooklyn	11	16	20	
Manhattan <14th St.	E. 10th St., NYC	18	10	14	66
Manhattan 14th–96th Sts.	E. 50th St., NYC	17	9	17	65
Manhattan > 96th St.	E. 110th St., NYC	18	7	20	64
Nassau	Mineola	13	17	45	
Queens	Queens	8	7	26	
Staten Island	Staten Island	28	26	13	
Suffolk	Hauppauge	42	40		
Westchester	Yonkers	27	17	29	54
Other NY Counties					
Albany	Albany	100	100	100	90
Broome	Binghamton		100		
Chautauqua	Jamestown	100			
Chemung	Elmira	100			
Chenango	Norwich	100			
Clinton	Plattsburgh	100			
Delaware	Sidney	100		100	
Dutchess	Poughkeepsie	89	82	87	26
Erie	Buffalo	100	100		
Essex	North Elba	100			100
Monroe	Rochester	100	100		100
Niagara	Niagara Falls			100	
Oneida	Utica				100

Table 9-2: One-Way Travel Distances Associated with Airport Facilities					
Origin/Destination		**Miles to/from[b]**			
County/Jurisdiction	**Surrogate Location**	**JFK**	**LGA**	**EWR**	**SWF**
Orange	Newburgh	76	65	71	6
Putnam	Carmel	100	54	75	35
Rockland	Nanuet	42	31	40	38
Saratoga	Saratoga Springs	100		100	
Suffolk	Brookhaven			59	
Sullivan	Monticello		94		39
Tompkins	Ithaca			100	
Ulster	Kingston	100		100	40
Washington	Kingsbury	100	100		
Yates	Milo		100		
Other NY[a]		100		100	
NJ Counties					
Atlantic	Egg Harbor Township	100		100	
Bergen	Hackensack	29	18	20	55
Burlington	Evesham Township	100	100	76	
Camden	Camden	100	100	76	
Cape May	Lower Township	100		100	
Essex	Newark	44	28	12	
Gloucester	Washington Township	50		91	
Hudson	Union City	22	15	13	
Hunterdon	Raritan Township			49	
Mercer	Hamilton Township	76	71	50	
Middlesex	Edison	46	46	20	
Monmouth	Middletown	57	55	32	
Morris	Parsippany-Troy Hills	51	40	24	
Ocean	Lakewood Township			48	
Passaic	Paterson	36	25	20	
Somerset	Franklin Township	53		27	
Sussex	Vernon Township			59	
Union	Elizabeth	32		4	
Warren	Philipsburg	100		60	
CT Counties					
Fairfield	Bridgeport	62	55	76	
Hartford	Hartford	100	100	100	
Litchfield	Torrington	100	100		
Middlesex	Middletown	100			
New Haven	New Haven	80	73	95	
Tolland	Vernon	100			
PA Counties					
Allegheny	Pittsburgh	100	100	100	
Beaver	Aliquippa	100			
Berks	Reading			100	
Bradford	Sayre			100	
Bucks	Bensalem			67	
Cambria	Johnstown	100			
Centre	Bellefonte	100			
Chester	West Chester			100	

Table 9-2: One-Way Travel Distances Associated with Airport Facilities					
Origin/Destination		Miles to/from[b]			
County/Jurisdiction	Surrogate Location	JFK	LGA	EWR	SWF
Cumberland	Carlisle	100		100	
Dauphin	Harrisburg	100		100	
Fayette	Uniontown			100	
Lackawanna	Scranton			100	
Lancaster	Lancaster	100		100	
Lehigh	Allentown	100		82	
Luzerne	Wilkes-Barre	100			
Lycoming	Williamsport	100		100	
Montgomery	Lower Merion	100		91	
Northampton	Bethlehem			72	
Philadelphia	Philadelphia	100		83	
Pike	Matamoros			80	37
Schuylkill	Pottsville			100	
Somerset	Somerset			100	
Susquehanna	Forest City			100	
Wayne	Honesdale			100	
Wyoming	Tunkhannock	100			
York	York	100			
Other PA[a]		100			
Other U.S. [a]		100	100	100	100

[a] These are cases where no county information was provided by survey respondent, and consequently a default distance was assigned.
[b] Trip distances are capped at a maximum of 100 miles.

Table 9-3: Average Travel Party Size by Travel Mode and Facility				
Travel Mode	Average Travel Party Size by Facility			
	JFK	LGA	EWR	SWF
Personal Car[a]	2.42	2.77	2.06	2.42
Rental Car[a]	2.42	2.77	2.06	2.42
Taxi	2.97	2.68	3.02	2.76
Limo/Towncar[a]	2.42	2.77	2.06	2.42
Shared-Ride Van[c]	10.8	10.8	10.8	10.8
Airport/Charter/Tour Bus[b]	45.86	45.86	45.86	45.86
Public/City Bus[b]	45.86	45.86	45.86	45.86
Hotel/Motel Shuttle Van[c]	10.8	10.8	10.8	10.8
Off-Airport Parking[d]	2.2	1.7	1.9	2.0

[a]Parsons Brinckerhoff et al. 2006.
[b]Excellent et al. 2008.
[c]Airlink et al. 2008.
[d] Port Authority, 2016b.

The trip distance data presented in Table 9-2 and the average party size data, which are shown in Table 9-3, along with the trip distribution data, were applied in developing the total VMT accumulated due to airport attracted travel. The methodology applied for estimating VMT is consistent for private cars, limousines, chartered buses, hotel/motel/off-airport shuttle buses, and van services vehicle categories, and is estimated using Equation 8-1.

$$VMT = \frac{N \times \%D}{P} \times L \quad (8\text{-}1)$$

Where,

N = number of passengers

%D = percent distribution by trip origin and travel mode

P = travel party size or vehicle occupancy in case of buses and shuttles

L = trip length (one-way)

For taxis servicing JFK, LGA, EWR, and SWF, taxi party size was estimated using the number of taxis dispatched (Port Authority 2015b). The number of taxis dispatched was allocated by trip origin/destination utilizing the percentage of airport passengers by trip origin/destination. The total passengers who used taxis were divided by total taxis dispatched to estimate overall party size (see Table 9-3). Data on total rental car transactions from Port Authority (Port Authority 2015b) is used to estimate total one-way rental car trips for JFK, EWR, and LGA. These trips are then multiplied by trip origin data for each airport to estimate rental car VMT. Rental car transactions at SWF were not available, so emissions at SWF are estimated like other categories.

Because no vehicle travel attraction statistics were available for TEB, based on the types of flights that use TEB, the number of passengers at TEB was estimated as the number of aircraft movements (Port Authority 2015a). TEB attracted travel VMT was 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 of 1.0. Once VMT was estimated for attracted travel at TEB, emissions were calculated in the same manner as for the other airports.

Once VMT estimates were developed for all attracted travel, VMT was summed by facility and mode. Emission factors for attracted travel at airports were calculated using EPA's MOVES model (EPA 2014a) based on input data for the 10 New York metropolitan counties (NYMTC, 2013). For personal vehicle travel (personal car, rental car, taxi, limo/town car), the emission factors were based on the weighted average of the MOVES passenger car, passenger truck, and motorcycle vehicle types over the 10 counties. Emission factors for shared-ride van, hotel/motel shuttle van, and off-airport parking were based on the 10-county weighted average small/medium truck emission factors. Emission factors for public/city bus and airport/charter/tour bus were based on the 10-county weighted average transit bus emission factors. Emissions estimates for all pollutants were developed by multiplying VMT by the corresponding emission factors (in grams per mile).

Cold-start emission factors for CO_2, CH_4, and N_2O associated with the startup of a cooled vehicle engine were applied to all personal vehicle trips. Vehicle emissions for this category were calculated by multiplying the number of vehicle trips with the corresponding weighted cold-start emission factor for each vehicle type. Total vehicle trips were estimated by dividing the total VMT for each vehicle type by the average trip distance for each airport/vehicle type

combination. The cold-start emission factors (in grams per start) by vehicle type and technology type were derived from the EPA MOVES model (EPA 2014a).

9.1.3 Results

Total airport attracted travel GHG emission estimates are displayed in Table 9-4 below. CO_2 accounted for more than 99% of all attracted travel CO_2e emissions.

Table 9-4: 2014 Airport Attracted Travel GHG Emissions by Mode (metric tons)

Airport	CO_2e	CO_2	CH_4	N_2O
Personal Car	483,683	482,116	5.2	4.7
Rental Car	34,844	34,717	0.4	0.4
Taxi	144,596	144,052	1.7	1.6
Limo/Town Car	87,366	87,049	1.0	1.0
Shared Ride Van	10,815	10,712	0.9	0.3
Airport/Charter/Tour Bus	4,314	4,255	2.3	0.0
Public/City Bus	2,329	2,297	1.2	0.0
Hotel/Motel Shuttle Van	4,569	4,526	0.4	0.1
Off-Airport Parking	3,985	3,971	0.0	0.0
Total	**776,501**	**773,695**	**13.1**	**8.1**

Total airport attracted travel CAP emission estimates are displayed in Table 9-5 below. Personal cars and taxis accounted for the largest share of all pollutants, although buses were also a significant contributor to NO_x and PM emissions.

Table 9-5: 2014 Attracted Travel CAP Emissions by Mode (metric tons)

Airport	SO_2	NO_x	$PM_{2.5}$	PM_{10}
Personal Car	9.6	281.9	15.5	70.6
Rental Car	0.7	20.9	1.1	5.1
Taxi	2.9	87.3	4.7	21.1
Limo/Town Car	1.7	52.2	2.8	12.8
Shared Ride Van	0.2	38.7	1.2	2.2
Airport/Charter/Tour Bus	0.0	55.9	2.6	3.5
Public/City Bus	0.0	30.2	1.4	1.9
Hotel/Motel Shuttle Van	0.1	16.3	0.5	0.9
Off-Airport Parking	0.1	2.4	0.1	0.6
Total	**15.2**	**585.9**	**30.0**	**118.7**

GHG and CAP emission estimates can also be broken down by airport, as shown in Table 9-6 and Table 9-7, respectively. JFK airport has the most GHG and CAP emissions, although EWR and LGA also account for a significant portion of the total.

Table 9-6: 2014 Attracted Travel GHG Emissions by Airport (metric tons)				
Airport	**CO_2e**	**CO_2**	**CH_4**	**N_2O**
JFK	320,230	319,071	6	3
EWR	273,907	272,949	4	3
LGA	176,795	176,126	3	2
SWF	4,251	4,237	0	0
TEB	1,319	1,312	0	0
Total	**776,501**	**773,695**	**13**	**8**

Table 9-7: 2014 Attracted Travel CAP Emissions by Airport (metric tons)				
Airport	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK	6	251	13	49
EWR	5	195	10	41
LGA	3	137	7	27
SWF	0	3	0	1
TEB	0	1	0	0
Total	**15**	**586**	**30**	**119**

9.2 AIR CARGO

In addition to passenger movement, there are also air cargo shipments that occur at the five Port Authority airports. These shipments are also included under attracted travel, and emissions from cargo traffic are also considered scope 3 sources. Direct emissions from cargo aircraft are discussed in Chapter 8.0 (there is no distinction made between passenger and cargo aircraft in emissions calculations). Therefore, attracted travel emissions come from delivery shipments (typically by truck) of cargo that has been delivered by the aircraft.

9.2.1 Activity Data

The primary data source for estimating attracted travel emissions from cargo shipments at the airports is a 2002 air cargo truck movement study for JFK (URS 2002). This provides data detailing cargo trips by route and vehicle type, and is used as a surrogate for cargo shipping at all Port Authority airports.

9.2.2 Method

JFK VMT for cargo-related travel was derived by multiplying the number of cargo trips by the estimated trip length of the access and egress routes obtained from the air cargo truck movement study conducted for JFK airport (URS 2002). Trip length by origin was estimated using Google Maps (see Table 9-8). The number of cargo trips at JFK in 2014 was estimated by scaling the number of trips estimated from the 2002 study by vehicle type based on the ratio of 2014 to 2002 freight cargo at JFK (Port Authority 2006; Port Authority 2015c). The resulting 2014 cargo VMT for JFK by

vehicle type was then scaled to LGA, EWR, and SWF airports using the 2014 ratio of cargo tons from JFK to the cargo tons at LGA, EWR, and SWF airports (Port Authority 2015c).

Table 9-8: One-Way Travel Distance Associated with JFK Airport for Cargo Travel	
Origin/Destination	**Miles to/from**
Van Wyck	5.10
On Airport	6.70
Rockway Blvd	2.80
Belt Parkway/Southern State	8.20
Other Routes[1]	5.70

Note: Only passenger vehicles are permitted on the Belt Parkway/Southern State Parkway. Therefore, only cargo trips using cars or mini-vans were allocated to this route.

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

9.2.3 Results

The GHG emission estimates from cargo trucks by airport are summarized in Table 9-9 below. JFK accounts for the majority of emissions from cargo shipments. TEB has no cargo shipments, and LGA and SWF have only a small amount.

Table 9-9: 2014 Cargo Truck Attracted Travel GHG Emissions by Airport (metric tons)				
Airport	**CO_2e**	**CO_2**	**CH_4**	**N_2O**
JFK	36,659	36,343	2	1
EWR	18,182	18,026	1	0
LGA	195	193	0	0
SWF	416	412	0	0
TEB	0	0	0	0
Total	**55,452**	**54,974**	**2**	**1**

Table 9-10 shows the CAP emission estimates from attracted travel - cargo trucks at the five Port Authority airports.

Table 9-10: 2014 Cargo Truck Attracted Travel CAP Emissions by Airport (metric tons)				
Airport	**SO_2**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**
JFK	1	103	6	11
EWR	0	51	3	5
LGA	0	1	0	0
SWF	0	1	0	0
TEB	0	0	0	0
Total	**1**	**156**	**8**	**16**

10.0 MOBILE COMBUSTION (SCOPE 3)

10.1 FERRY MOVEMENTS

The Port Authority owns the installation of the WFC terminal located off Vessey Street in Lower Manhattan, and outsources ferry operations to NY Waterway and Liberty Landing Ferries, LLC. This category represents combustion emissions from ferry movements arriving to and departing from the WFC terminal. Ferry movements and associated emissions were estimated for the following five routes that were in service during 2014:

- Belford–WFC
- Port Imperial–WFC (via Hoboken North)
- Hoboken South[2]–WFC
- Paulus Hook–WFC
- Liberty Landing–WFC (via Warren Street)

10.1.1 Activity Data

Ferry movement emissions are estimated as a function of a vessel's running time and diesel-engine specifications. Ferry operating schedules and unit count of vessels servicing each route served as key information for determining the total number of ferry-hours in a year (Port Authority 2015d; Port Authority 2016a). For each route, annual running time (ferry-hours/year) was calculated as the product of the ferry count, the daily running time (hours/day), and the number of operating days in 2014[3] (days/year). Annual running time assessments by route are summarized in Table 10-1. Note that the annual running time is an important metric because it represents the maximum number of hours attributable to a ferry route.

Table 10-1: WFC Schedules and Annual Running Times by Route

Route	Time Period	Schedule Type	Ferry Count	Daily Running Time (hours/day)	Operating Schedule (days/year)	Annual Running Time (ferry-hours/year)
Belford–WFC	AM	Weekday	3	4.58	249	3,424
	PM	Weekday	3	7.25	249	5,416
Port Imperial–WFC	AM	Weekday	1	4.47	249	1,112
	PM	Weekday	3	4.92	249	3,673
Hoboken South–WFC	AM/PM	Weekday	2	15.67	249	7,802
Paulus Hook–WFC	AM/PM	Weekday	2	15.82	249	7,877
	AM/PM	Weekend	1	12.13	104	1,262

[2] Hoboken South is also known as Hoboken/NJ Transit Terminal.
[3] Weekday ferries operated on 249 non-holiday weekdays and the weekend ferries operated on 104 Saturdays and Sundays in 2014.

Table 10-1: WFC Schedules and Annual Running Times by Route						
Route	**Time Period**	**Schedule Type**	**Ferry Count**	**Daily Running Time (hours/day)**	**Operating Schedule (days/year)**	**Annual Running Time (ferry-hours/year)**
Liberty Landing–WFC	AM/PM	Weekday	1	15.00	249	3,735
	AM/PM	Weekend	1	11.00	104	1,144

Annual running times were broken down between cruising and idling time. Cruising occurs when ferries are in transit between terminal stops, and idling corresponds to the time when ferries are at berth. For each route, cruising time was calculated as the product of the number of annual trips and the average trip duration. Idling time was calculated as the difference between the annual running time and annual cruising time and presumes that marine engines are continuously running during the time period labeled "daily running time hours" in Table 10-1. The analysis did not differentiate between time spent idling at the WFC terminal and time idling at other ports. A summary of cruising and idling hours per vessel is included in Table 10-2.

Ferry operators provided marine engine information for the vessels assigned to each ferry route (Port Authority 2016a). Key specifications included the number of engines, engine power rating, engine tier (i.e., air emissions performance standard), and the model year of the engine. Running, cruising, and idling times were mapped to each vessel's engine specification and were then correlated to the corresponding emission factor as discussed in Section 10.1.2. Table 10-2 summarizes ferry activity data used as input to the emissions methodology. All of the engines listed in Table 10-2 are Category 1 (small, non-ocean going) propulsion engines and none of the vessels listed were reported to have auxiliary engines.

Table 10-2: Summary of Ferry Activity Data								
Route	**Vessel Name**	**Engine Count**	**Model Year**	**Engine Tier**	**Engine Power (kW/engine)**	**Running Time (hrs/yr)**	**Cruise Time (hrs/yr)**	**Idling Time (hrs/yr)**
Belford–WFC	Finest	2	1996	1	533	2,947	1,660	1,287
	Bravest	2	1996	1	533	2,947	1,660	1,287
	Con. Robert Roe	4	2003	1	447	2,947	1,660	1,287
Hoboken South–WFC	Brooklyn	4	2002	1	447	3,901	2,158	1,743
	Sen. Frank Lautenberg	4	2002	1	447	3,901	2,158	1,743
Port Imperial–WFC	Gov. Thomas Kean	4	2003	1	447	2,336	1,848	488
	Bayonne	4	2003	1	447	1,224	852	372
	Jersey City	4	2003	1	447	1,224	852	372
Paulus Hook–WFC	Jersey	2	2010	2	447	3,938	3,442	496
	York	2	2010	2	447	5,200	4,619	581
Liberty Landing–WFC	Little Lady II	2	2007	2[a]	447	4,879	4,630	249

[a] Port Authority-provided data listed these engines as Tier 0; however, applicable regulations mandate that a model-year 2007 engine should be at

least Tier 2. Therefore, SC&A assigned these engines to Tier 2.

10.1.2 Method

GHG and CAP emissions were estimated for each engine as a function of engine characteristics (i.e., a combination of engine power rating, model year, and engine tier), hours of operation, and load factor. PM_{10} emissions 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 10-1.

$$Emissions = P \times T_m \times EF_{i,q} \times LF_m \times DF_j \qquad (10\text{-}1)$$

Where,

P = engine power rating (kW)

T = annual hours of operation in operating mode "m" (hours)

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

LF = load factor specific to operating mode "m" (unitless)

DF = deterioration factor specific to age of engine "j" (unitless); applies only when "q" is PM

i = engine type (determined by power rating and engine tier)

j = age of engine (years)

m = operating mode (cruising or idling)

q = pollutant

The emission factors used in this analysis are documented as the streamlined/alternative approach in EPA's report on Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories (EPA 2009). This publication provided the best available emission factor information for small diesel marine engines denoted by EPA as Category 1. The ferries servicing the WFC terminal do not combust marine diesel but instead use ultra-low sulfur diesel (ULSD) exclusively. This is an important consideration because ULSD diesel has a low sulfur content of 15 ppm, while conventional marine diesel has a high sulfur content of 15,000 ppm. The use of ULSD has the effect of abating PM and SO_2 emissions from ferry movements associated with the WFC terminal. Therefore, default PM_{10}, $PM_{2.5}$ and SO_2 emissions to factors were adjusted down according to EPA's methodology (EPA 2009).

Because marine engine emissions vary according to the mode of operation, the emission factors were multiplied by a cruising or idling load factor. In the streamlined/alternative approach, EPA recommends using the ferry-specific cruising load factor of 42% from a Port of Long Beach study (EPA 2009). Based on a literature review, EPA determined that idling load factors for ferries are roughly 20% less than cruising load factors (EPA 2000; EPA 2008). Therefore, SC&A used an idling load factor of 22%.

The PM emission factors are then multiplied by a deterioration factor to account for increasing emissions as engines

age, as suggested by EPA. This deterioration factor was calculated as the product of the relative deterioration factor (DF) and estimated engine age divided by the median life of Category 1 propulsion engines, as can be seen in Equation 10-2 (EPA 2008).

$$Deterioration\ Factor = 1 + A \times \left(\frac{age}{ML}\right) \tag{10-2}$$

Where,

A = Relative Deterioration Factor (unitless)

age = Age of engine as of the year of the assessment (years)

ML = Median lifetime of this type of marine vessel (years)

The relative DF (0.473) and median lifetime (13 years) for Category 1 propulsion engines at all engine tiers are provided by EPA. After the first median life, EPA holds the DF constant for the remaining life of the engine. Therefore, the maximum DF applied to PM emissions in this analysis was 1.473, which is an increase of 47.3% over PM emissions from a new, but otherwise identical engine. (EPA 2008).

10.1.3 Results

The GHG emission estimates from ferry movements associated with the WFC terminal in 2014 are summarized in Table 10-3.

Table 10-3: 2014 GHG Emissions from Ferries, by Route and Operating Mode (metric tons)

Route and Operating Mode	CH_4	CO_2	N_2O	CO_2e	% of CO_2e
Belford–WFC	**0.35**	**2,652.94**	**0.08**	**2,684.04**	**23.09%**
Idling	0.10	766.00	0.02	774.99	6.67%
Cruising	0.25	1,886.93	0.05	1,909.06	16.43%
Hoboken South–WFC	**0.42**	**3,185.54**	**0.09**	**3,222.89**	**27.73%**
Idling	0.12	947.05	0.03	958.16	8.24%
Cruising	0.29	2,238.49	0.06	2,264.74	19.49%
LSP Water Taxi	**0.16**	**1,234.50**	**0.04**	**1,248.97**	**10.75%**
Idling	negl.	33.82	negl.	34.22	0.29%
Cruising	0.16	1,200.67	0.03	1,214.75	10.45%
Paulus Hook–WFC	**0.29**	**2,236.89**	**0.06**	**2,263.11**	**19.47%**
Idling	0.02	146.27	negl.	147.98	1.27%
Cruising	0.27	2,090.62	0.06	2,115.13	18.20%
Port Imperial–WFC	**0.28**	**2,177.30**	**0.06**	**2,202.83**	**18.95%**
Idling	0.04	334.85	0.01	338.78	2.92%
Cruising	0.24	1,842.45	0.05	1,864.05	16.04%
Total	**1.50**	**11,487.16**	**0.33**	**11,621.85**	**100.00%**
Idling	**0.29**	**2,228.00**	**0.06**	**2,254.12**	**19.40%**
Cruising	**1.21**	**9,259.16**	**0.27**	**9,367.72**	**80.60%**

The CAP emission estimates from ferry movements associated with the WFC terminal in 2014 are summarized in Table 10-4.

Table 10-4: 2014 CAP Emissions from Ferries, by Route and Operating Mode (kilograms)						
Route and Operating Mode	**CO**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**
Belford–WFC	**5,767.25**	**37,679.40**	**1,428.23**	**1,385.39**	**24.99**	**1,038.11**
Idling	1,665.23	10,879.49	412.39	400.01	7.22	299.74
Cruising	4,102.03	26,799.91	1,015.85	985.37	17.78	738.36
Hoboken South–WFC	**6,925.10**	**45,243.96**	**1,711.18**	**1,659.84**	**30.01**	**1,246.52**
Idling	2,058.81	13,450.91	508.73	493.47	8.92	370.59
Cruising	4,866.28	31,793.05	1,202.45	1,166.37	21.09	875.93
LSP Water Taxi	**8,945.63**	**12,166.05**	**579.16**	**561.78**	**11.63**	**483.06**
Idling	245.10	333.33	15.87	15.39	0.32	13.24
Cruising	8,700.53	11,832.72	563.29	546.39	11.31	469.83
Paulus Hook–WFC	**16,209.32**	**22,044.67**	**958.13**	**929.39**	**21.07**	**875.30**
Idling	1,059.90	1,441.47	62.65	60.77	1.38	57.23
Cruising	15,149.41	20,603.20	895.48	868.61	19.69	818.07
Port Imperial–WFC	**4,733.26**	**30,923.98**	**1,139.96**	**1,105.76**	**20.51**	**851.99**
Idling	727.94	4,755.86	175.32	170.06	3.15	131.03
Cruising	4,005.33	26,168.13	964.64	935.70	17.36	720.96
Grand Total	**42,580.56**	**148,058.06**	**5,816.65**	**5,642.15**	**108.21**	**4,494.98**
Idling	**5,756.98**	**30,861.05**	**1,174.95**	**1,139.70**	**20.99**	**871.83**
Cruising	**36,823.58**	**117,197.01**	**4,641.71**	**4,502.45**	**87.22**	**3,623.15**

With the input of the Port Authority, it was assumed that all engines on all vessels for a given route were started at the beginning of the running period and none of the engines were stopped until the end of the running period. This assumption resulted in the determination that 30% of the total weekday daily ferry-hours are spent idling at a port. The percentage of time each route spends idling is summarized in Table 10-5. If anti-idling measures were implemented by ferry operators in 2014, idling emission estimates will need to be revised down.

Table 10-5: Idling Time per Route as Percent of Daily Ferry-Hours					
Schedule Type	**Route**	**Ferry Count**	**Daily Running Time (ferry-hrs)**	**Daily Idling Time (hrs)**	**% Running Time Spent Idling**
Weekday	Belford–WFC (AM)	3	13.75	4.58	33%
	Belford–WFC (PM)	3	21.75	10.92	50%
	Port Imperial–WFC (AM)	1	4.47	0.47	10%
	Port Imperial–WFC (PM)	3	14.75	4.48	30%
	Hoboken South–WFC	2	31.33	14.00	45%
	Paulus Hook–WFC	2	31.63	3.98	13%
	LSP Water Taxi	1	15.00	1.00	7%
	Total	**11**	**132.68**	**39.43**	**30%**

Table 10-5: Idling Time per Route as Percent of Daily Ferry-Hours					
Schedule Type	**Route**	**Ferry Count**	**Daily Running Time (ferry-hrs)**	**Daily Idling Time (hrs)**	**% Running Time Spent Idling**
Weekend	Paulus Hook–WFC	1	12.13	0.82	7%
	LSP Water Taxi	1	11.00	0.00	0%
	Total	**2**	**23.13**	**0.82**	**4%**

10.2 SHADOW FLEET

The shadow fleet consists of vehicles that are owned by the Port Authority but are operated on a day-to-day basis by contractors or tenants. Because they are not operated by the Port Authority directly, they do not fall within the purview of the CAD (discussed in Chapter 3.0), and are considered scope 3 sources.

10.2.1 Activity Data

Data on the shadow fleet were provided by the Port Authority (Port Authority 2015b). In 2014, the shadow fleet consisted of fuel trucks and shuttle buses at JFK, EWR, and LGA.

In the 2013 inventory there were also a few shadow fleet vehicles that operated at TEB and SWF, but there was no information provided on these vehicles in 2014. Therefore, there are no shadow fleet emissions estimated for SWF and TEB.

10.2.2 Method

Port Authority provided diesel and gasoline fuel consumption from the shadow fleet. These were then multiplied by the appropriate TCR emission factors to estimate GHG emissions and MARKAL emission factors to estimate the criteria pollutants.

10.2.3 Results

GHG emission estimates are summarized by airport in Table 10-6 below. Shadow fleet emissions come from both shuttle buses and fuel trucks, with JFK and EWR accounting for the majority of the total. CAP emission estimates by airport are shown in Table 10-7.

Table 10-6: 2014 Shadow Fleet GHG Emissions by Airport (metric tons)					
Airport	**CO_2e**	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
JFK	6,990	6,833	775	0.4	0.5
EWR	4,581	4,478	408	0.3	0.3
LGA	1,144	1,118	259	0.1	0.1
SWF	0	0	0	0.0	0.0
TEB	0	0	0	0.0	0.0
Total	**12,714**	**12,428**	**1,442**	**1**	**1**

Table 10-7: 2014 Shadow Fleet CAP Emissions by Airport (metric tons)				
Airport	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK	0.5	13.5	2.1	2.3
EWR	0.3	8.4	1.3	1.4
LGA	0.0	1.6	0.1	0.1
SWF	0.0	0.0	0.0	0.0
TEB	0.0	0.0	0.0	0.0
Total	**0.7**	**23.5**	**3.5**	**3.8**

11.0 REFERENCES

ACRP 2009. *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*. Airport Cooperative Research Program, Report 11. Located online at http://www.trb.org/Publications/Blurbs/160829.aspx

Airlink et al. 2008. *Shared-Ride/Van Service Passenger Capacity*, available at Airlink Shuttle, Carmel and Limousine Service, and Classic Limousine websites, October 2008.

ATADS 2015. *Air Traffic Activity Data System*, Federal Aviation Administration, accessed at http://aspm.faa.gov/opsnet/sys/Main.asp?force=atads in December 2015.

Calpine 2015. File prepared by Wayne Goonan, Calpine, *QF 2014PA.xlsx*, sent to J. Schreiber, SC&A Inc. November 14, 2015.

EIA 2003. *Commercial Buildings Energy Consumption Survey, Table E2. Major Fuel Consumption (Btu) Intensities by End Use for Non-Mall Buildings*, U.S. Energy Information Administration. Revised December 2008. Available at http://www.eia.gov/consumption/commercial/data/2003/pdf/e02a.pdf

EIA 2007. *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy*, Table 4, U.S. Energy Information Administration. May 2007. Available online at http://www.eia.gov/totalenergy/data/monthly/pdf/historical/msw.pdf

EIA 2015. *EIA Weekly Retail Data, for Middle Atlantic Region*, U.S. Energy Information Agency. Available at http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html

EPA 1995. *AP-42 Compilation of Air Pollutant Emission Factors*, U.S. Environmental Protection Agency, Office of Transportation and Air Quality. January 1995. Accessible on the web at http://www.epa.gov/ttn/chief/ap42/

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

EPA 1998. *Emission Factor Documentation for AP-42 Section 1.4: Natural Gas Combustion*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. July 1998.

EPA 2000. *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data*, EPA420-R-00-002, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, prepared by Energy and Environmental Analysis, Inc. February 2000.

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

EPA 2008. *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder*, EPA420-R-08-001, U.S. Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. March 2008.

EPA 2009. *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*, Final Report, U.S. Environmental Protection Agency, Office of Policy, Economics and Innovation, prepared by ICF International. 09-024. April 2009.

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

EPA 2010b. *AP-42 Compilation of Air Pollutant Emission Factors*, Chapter 1, *External Combustion Sources*, Section 1.3, U.S. Environmental Protection Agency, Office of Transportation and Air Quality. Updated May 2010. Available at http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s03.pdf

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

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

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

EPA 2013b. *Air Markets Program Data*, U.S. Environmental Protection Agency. Available at http://ampd.epa.gov/ampd/

EPA 2014a. *"Motor Vehicle Emissions Simulator MOVES2014,* U.S. Environmental Protection Agency. Released December 2014. For more information, see http://www.epa.gov/otaq/models/moves/

EPA 2014b. *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012.* Available at http://www.epa.gov/osw/nonhaz/municipal/pubs/2012_msw_fs.pdf

EPA 2015a. "*2014 Greenhouse Gas Emissions from Large Facilities*, EPA Flight Database. Accessed November 14, 2015. Located online at: http://ghgdata.epa.gov/ghgp/main.do

EPA 2015b. *Emissions & Generation Resource Integrated Database*, U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Protection Partnerships Division. Latest release date, October 8, 2015. Located online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/

Excellent et al. 2008. *Chartered Bus Passenger Capacity*, available at Excellent Bus Service Inc., Leprechaun Bus Line, and Classic Limousine websites, October 2008.

FAA 2012. *Glossary*, Federal Aviation Administration, accessed online at http://aspmhelp.faa.gov/index.php/Glossary

IPCC 1996. *Working Group I: The Science of Climate Change*, Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York. 1996.

IPCC 2001. *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Watson, R.T. and the Core Writing Team (eds.). Cambridge University Press, Cambridge and New York. 2001.

IPCC 2006. *2006 IPCC Guidelines for National Greenhouse Gas Emission Inventories*, Intergovernmental Panel on Climate Change, Hayama, Kanagawa, Japan. 2006.

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

Mandatory Greenhouse Gas Reporting, 40 C.F.R. Part 98

NYMTC, 2013. New York Metropolitan Transportation Council provided MOVES emission factors for NY Area in a personal email communication between Afolabi, Aiyedun and Maureen Mullen in December, 2013.

Parsons Brinckerhoff et al. 2006. *FAA Regional Air Service Demand Study – PANYNJ Air Passenger Survey Findings Final Report*. April 19, 2006.

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

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

Port Authority 2006. *2006 Annual Airport Traffic Report*, Port Authority of New York & New Jersey. 2006.

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

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

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

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

Port Authority 2014a. *Greenhouse Gas and Criteria Air Pollutant Emission Inventory for the Port Authority of New York & New Jersey, Calendar Year 2011.* Prepared by Southern Research Institute and SC&A, Inc. January 2014.

Port Authority 2014b. *Request for Information for Replacement, Rehabilitation or Redesign of the Cogeneration Plant and Related Infrastructure at John F. Kennedy International Airport*, Port Authority of New York & New Jersey. May 8, 2014. Available at http://www.panynj.gov/business-opportunities/pdf/RFIDOC_37799.pdf.

Port Authority 2015a. *RE: 2013 Tenant Electricity Usage*, Port Authority of New York & New Jersey, Email correspondence from Katharine Targett. March 6, 2015.

Port Authority 2015b *2014 GHG Inventory Master Spreadsheet Dec2015.xlsx*. *Master Vehicle List, Master Shadow Fleet List* and *Master GSE List* are embedded sheets in file.

Port Authority 2015c. *Airport Traffic Report 2014*. April 2015. Located online at: http://www.panynj.gov/airports/pdf-traffic/ATR_2014.pdf

Port Authority 2015d. *BPCFT FERRY SCHEDULE.xlsx*. Provided by email December 15, 2015.

Port Authority, 2015e. *Port Authority Annual Report 2014.* June 2015. Annual Reports located online at http://corpinfo.panynj.gov/pages/annual-reports/

Port Authority 2016a. *Copy of Fleet Chart.xlsx*. Provided by email May 3, 2016.

Port Authority 2016b. *2015 TxT CSS Dep O-D Party Size By Select Airport Access Modes - nate request.xlsx.* Provided by email on 7/20/2016.

Starcrest, 2016: Starcrest Consulting Group, LLC, "The Port of New York and New Jersey Port Commerce Department 2014 Multi Facility Emissions Inventory of Cargo Handling Equipment, Heavy Duty Diesel Vehicles, Railroad Locomotives and Commercial Marine Vessels," prepared for the Port Authority of New York and New Jersey, February 2016.

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

TCR 2010. *Local Government Operations Protoco*l, Version 1.1, The Climate Registry. May 2010.

TCR 2013a. *General Reporting Protocol – Version 2.0*, The Climate Registry March 2013. Available at http://www.theclimateregistry.org/wp-content/uploads/2014/11/TCR_GRP_Version_2.0-1.pdf.

TCR 2013b. *2013 Climate Registry Default Emission Factors.* Updated April 2, 2013.

TCR 2015. *2015 Climate Registry Default Emission Factors*. April 2015.

URS 2002. *John F. Kennedy International Airport – Air Cargo Truck Movement Study*, URS Corporation, prepared for Port Authority of New York & New Jersey Traffic Engineering. May 2002.

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

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

WPCI, 2010: World Ports Climate Initiative. "Carbon Footprinting for Ports, Guidance Document," prepared by Carbon Footprinting Working Group, June 2010.

WRI 2004. World Resources Institute and World Business Council for Sustainable Development. *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition*. March 2004.

APPENDIX A: SCOPE 3 GHG EMISSIONS BY YEAR OF ASSESSMENT

Department	Emission Category	Activity	MtCO2e	Year of Last Assessment
Aviation	Aircraft	Aircraft Movements	1,625,013	2014
		Auxiliary Power Units	31,920	2014
		Ground Support Equipment	174,576	2014
	Attracted Travel	Air Cargo	55,452	2014
		Airport Passenger	776,501	2014
	Energy Production	Electricity Sold to Market	153,810	2014
	Purchased Cooling	Buildings	11,452	2014
	Purchased Electricity	Buildings	162,199	2013
	Purchased Heating	Buildings	9,329	2013
	Stationary Combustion	Buildings	26,001	2013
Central Administration	Mobile Combustion	Shadow Fleet	12,714	2014
Engineering	Construction	Non-Road Diesel Engines	15,849	2013
Multi-Department	Mobile Combustion	Employee Commuting	21,353	2013
PATH	Attracted Travel	PATH Passenger	60,064	2012
	Purchased Electricity	Buildings	70	2013
	Stationary Combustion	Buildings	30	2013
Planning	Mobile Combustion	Ferry Movements	11,622	2014
	Purchased Electricity	Buildings	123	2013
	Stationary Combustion	Buildings	50	2013
Port Commerce	Attracted Travel	Commercial Marine Vessels	150,953	2014
		Drayage Trucks, to NYNNJLINA boundary	266,862	2014
		Drayage Trucks, from NYNNJLINA to first point of rest	684,937	2012
	Mobile Combustion	Auto Marine Terminal, Vehicle Movements	402	2012
		Cargo Handling Equipment	104,525	2014
		Rail Locomotives	18,022	2014
	Purchased Electricity	Buildings	7,615	2014
	Stationary Combustion	Buildings	3,257	2013
Real Estate	Energy Production	Electricity Sold to Market	359,652	2014
	Purchased Electricity	Buildings	104,162	2013
	Stationary Combustion	Buildings	47,525	2013
Tunnels, Bridges & Bus Terminals	Attracted Travel	Queued Traffic	22,107	2012
		Through Traffic	523,933	2013
	Purchased Electricity	Buildings	2,281	2013
	Stationary Combustion	Buildings	364	2013
Scope 3 Emissions Total			**5,448,766**	