Greenhouse Gas Emissions Inventory
Government Operations
City of Hoboken, New Jersey
Activities Year 2017

April 2019

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LIST OF ACRONYMS

AR5 - Intergovernmental Panel on Climate Change's Fifth Assessment Report
CAGR – Compound Annual Growth Rate
CH_4 - methane
CO_2 – carbon dioxide
CO_2e - Carbon Dioxide Equivalents
CSC – New York State Climate Smart Communities
EF – GHG Emission Factor
eGRID – US EPA Emissions & Generation Resource Integrated Database
EPA – Environmental Protection Agency
GHG – greenhouse gas
GPC – Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP – global warming potential
HFC – hydrofluorocarbon
ICLEI - Local Governments for Sustainability
IMP – Inventory Management Plan
IPCC – Intergovernmental Panel on Climate Change
LGO – Local Government Organization
LGOP – ICLEI's Local Government Organization Protocol
LPG – liquid petroleum gas (propane)
t – metric tonnes
MSW – municipal solid waste
MWh – Mega Watt hour
NHSA - North Hudson Sewerage Authority
N_2O – Nitrous Oxide
PFC – perfluorocarbon
RFCE – NERC region: Reliability First Corporation/ East
SF_6 – sulfur hexafluoride
TCR – The Climate Registry
the City – City of Hoboken
US EPA - United States Environmental Protection Agency
UNFCCC – United Nations Framework Convention on Climate Change
WRI – World Research Institute

Executive Summary

First Environment, Inc. (First Environment) was retained by the City of Hoboken (Hoboken or the City) to prepare the greenhouse gas (GHG) emissions inventory for both the community and the municipal operations activities of year 2017. The community GHG inventory was prepared in accordance with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), developed by the Local Governments for Sustainability (ICLEI) in partnership with the World Resources Institute. The municipal operations GHG inventory was prepared in accordance with ICLEI's Local Government Operations Protocol (LGOP). ICLEI's ClearPath Pro web based tool provided the platform for data collection, processing, and GHG quantification and reporting for both inventories.

The GHG inventory assessed emissions of seven greenhouse gases (GHGs):

- carbon dioxide (CO_2),
- methane (CH_4),
- nitrous oxide (N_2O),
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs),
- sulfur hexafluoride (SF_6), and
- Nitrogen tri-fluoride (NF_3).

Conducting the GHG inventories demonstrates the City's recognition of its relationship to both the local and global environment. It allows the City to better understand and take responsibility for its activities and their climate impacts. Accordingly, the inventories provide a foundation and starting point for the City's efforts to reduce GHG emissions from its activities and demonstrate environmental stewardship. The inventories serve as a reference point to guide the development of policies, programs, and projects as the City pursues its climate change mitigation and adaption objectives.

This report addresses the municipal operations GHG inventory emissions; a separate report was prepared for the community GHG emissions.

Municipal Operations Inventory

The scope of the inventory included all emissions sources under the City's operational control. This consisted of the City's Scope 1 "direct" emissions from stationary combustion and mobile combustion, as well as Scope 2 "indirect" emissions from the consumption of purchased electricity. In accordance with the LGOP, the inventory does include any City Scope 3 emissions.

Emissions in the GHG Inventory are reported in Carbon Dioxide Equivalents (CO_2e). CO_2e is used to quantify total emissions because each GHG has a different Global Warming Potential (GWP) which is converted to CO_2e by using a gas specific factor. Unless otherwise noted in this report, GHG emissions were converted to CO_2e using Global Warming Potentials (GWPs), a standard conversion factor, from the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5). Using CO_2e equalizes all GHGs to one standard reference, quantified in metric tonnes of carbon dioxide equivalent (tCO2e), the global standard unit used to measure GHG emissions.

Table 1: Summary of GHG Inventory

Reporting Protocol	Local Governments for Sustainability (ICLEI)'s Local Government Operations Protocol, v1.1, May 2010
Reporting Tool	ICLEI ClearPath – Government Track - https://clearpath.icleiusa.org
Geographic Boundary	City of Hoboken Municipal Boundary
Organizational Boundary	Operational Control
Operational Boundary	Scope 1, Scope 2
Inventory Reporting Period	January 1 to December 31, 2017
Base Year	2017
GWP Defaults	IPCC 5th Assessment Report (AR5)

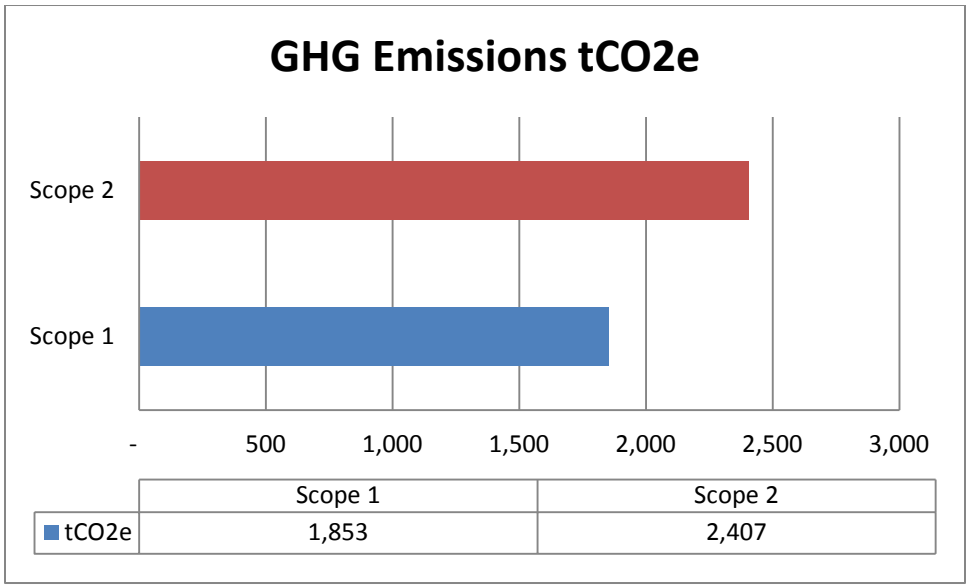
The City's total Scope 1 GHG emissions for 2017 amounted to 1,852 tCO_2e. These total emissions originate from stationary combustion, such as natural gas for heating, and mobile combustion, such as gasoline and diesel consumption by the City fleet vehicles.

The City's total Scope 2 GHG emissions for 2017 amounted to 2,407 tCO_2e.

Table 2: Total GHG Emissions by Scope (tCO_2e)

GHG Emissions	tCO_2e
Scope 1	1,853
Scope 2	2,407
Total	**4,260**

Figure 1: Total GHG Emissions by Scope (tCO_2e)



The distribution of Scope 1 and Scope 2 emissions by sector is shown in percentage and in tCO_2e in the charts below.

Figure 2: Total GHG Emissions by Sector in Percentage

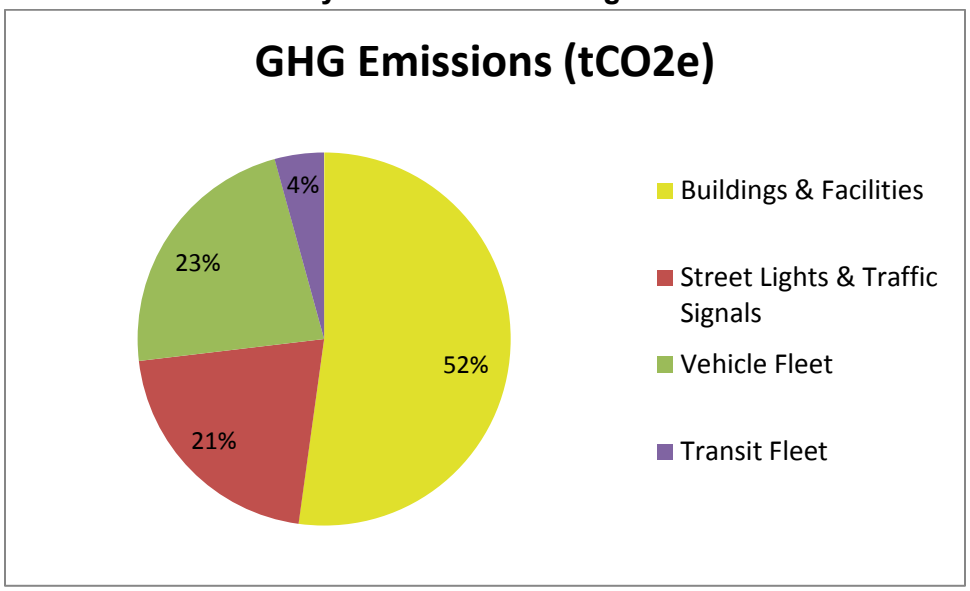
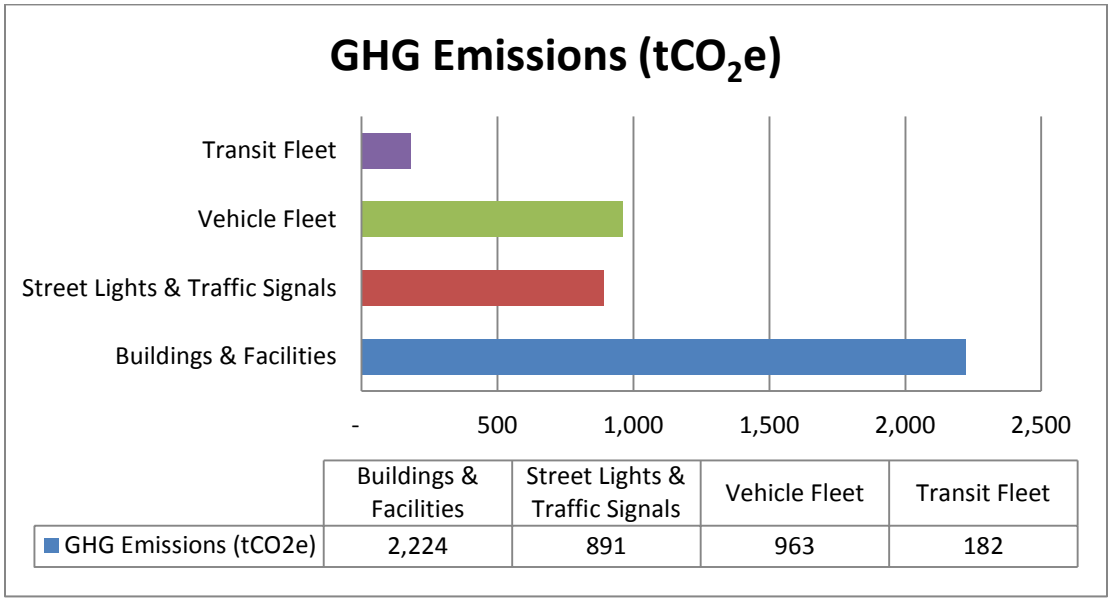


Figure 3: Total GHG Emissions by Sector (tCO_2e)



The results highlight the predominance of the building and facilities as the major source of GHG emissions. Scope 1 emissions (mobile fuel combustion) from the vehicle fleet and electricity consumption by streetlights are almost equal, ranking as the next largest sources. Mobile emissions by the City-operated transit fleet ranks fourth.

1. Introduction

A GHG emissions inventory identifies an organization's GHG emission sources and quantifies them according to a set of acknowledged conventions using established estimation methodologies.

The City air emission inventory quantifies GHG from the "Kyoto six" GHGs—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) plus the additional nitrogen tri-fluoride (NF_3), recently included to the reportable GHGs. These are the most recognized and common GHGs from human-made sources, as identified in the United Nations Framework Convention on Climate Change Kyoto Protocol (UNFCCC).

The GHG inventory of local government operations (LGO) identifies the amounts of electricity and fuels used in municipal buildings, streetlights, fleets, and other operations controlled by the local government. If operated by the City, GHG emissions from waste and water treatment facilities would also be included, but this is not the case for the City of Hoboken.

The LGO inventory does not include GHG emissions generated by the City residents and businesses, including those produced by power generation facilities, if present. The emissions from these sources are accounted for separately and constitute the Community GHG emissions inventory, which are reported under a different Protocol (U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions). First environment quantified the City of Hoboken Community GHG Inventory for calendar year 2017 in a separate report.

2. Overview of the City of Hoboken

The City of Hoboken is located in Hudson County, New Jersey, across the Hudson River west of New York City.

According to the United States Census Bureau[1], the town has a total area of 2.011 square miles including 1.275 square miles of land. The population according to the 2010 census data was 50,006 and it has increased to 55,131 as estimated by July 1, 2017. The City territory borders the municipalities of Jersey City to the west and south, Union City and Weehawken on the north side. The Hudson River flows on the eastern side of the City.

The City was formed as a Township in 1849 and incorporated as a City in 1855.

The City government staff is composed of 528 full time employees and 251 part-time/seasonal employees as of November 2018.

Table 3: City Government Staff by Department

Department	Full Time Employees
Finance	13
Human Services	24
Administration	59
Public Safety	276
Community Development	9
Environmental Services	53
Hoboken Parking Unit	90
Mayor's Office	4

The City operates several facilities and buildings, summarized by Department in the table below. A detailed schedule of properties is attached in Appendix 1.

Table 4: Buildings and Facilities with the City Operations

City Departments	Square feet Area of Facilities
Hoboken Volunteer Ambulance Corps	3,800
Environmental Services Department	595,216
City Hall	20,400
Fire Department	20,505
Hoboken Parking Utility	424,067
Transportation & Parking Department	12,356
Human Services Department	40,000
Police Department	23,242
Hoboken Public Library	50,000
Boys & Girls Club	2,500

[1] https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

All the buildings and facilities listed are either owned and operated by the City or the City is ultimately responsible for paying the utilities for them. These include electricity and natural gas for heating.

In addition to the buildings and facilities listed above, the City operations also include the street lighting and traffic lights, metered independently from the building and facilities. The electricity for street lighting and for the building and facilities is provided by the local utility (PSE&G). According to a recent inventory provided by PSE&G, there were 2,836 metered streetlights and 23 traffic lights in operation within the City of Hoboken.

The City does not operate waste disposal facilities or wastewater treatment facilities, though the North Hudson Sewerage Authority (NHSA) operates a wastewater treatment facility located on Adams Street on the northern end of the Hoboken territory.

The City operates several fleets of vehicles for the various departments, including police and fire department, environmental services, the Hoboken Parking Unit (HPU), and a fleet of five paratransit buses providing public transit within the City territory. The fleet consists of different type of vehicles including passenger cars, pickups, heavy trucks for road maintenance equipment, sanitation, etc. The fleet uses both diesel and gasoline fuel.

2.1 Staff Responsible for the GHG Inventory

This GHG inventory was developed by First Environment through consultation with the City staff led by Jennifer Gonzales, Director of Environmental Services, Chief Sustainability Officer.

2.2 GHG Inventory Reporting Protocol

The City of Hoboken Government Operations GHG inventory was conducted in accordance with the ICLEI's Local Government Operations Protocol (LGOP), Version 1.1, May 2010. The LGOP was developed through a partnership among the California Air Resources Board (ARB), California Climate Action Registry (CCAR), The Climate Registry, and ICLEI. The LGOP is based on the "Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard" developed by the World Business Council for Sustainable Development and the World Resources Institute (WRI/WBCSD), which provides the standards and guidance for companies and other types of organizations preparing a GHG emissions inventory. The goal of the LGOP is to offer additional guidance to local governments on applying the GHG Protocol within the context of local government operations. The LGOP provides a standardized method and procedures to assist local governments in quantifying and reporting GHG emissions associated with their operations.

2.3 GHG Inventory Reporting Tool

The GHG inventory was prepared using ICLEI's ClearPath Tool, an online platform designed to incorporate all the LGOP requirements for inventory data including all parameters, factors, and methodologies necessary to perform the GHG emissions quantification. The ClearPath suite of tools also includes modules allowing forecasting of emissions scenarios, as well as planning and monitoring of measures aimed at reducing GHG emission over time.

2.4 GHG Inventory Reporting Period – Base Year

This GHG inventory report covers GHG emissions form the City operations within the boundaries described below during the period of:

- January 1 through December 31, 2017.

This first GHG Inventory provides a full calendar year baseline of data about the energy consumption and resulting GHG emissions from the City municipal operations. The baseline will be used to establish emissions reductions targets and track progress towards achieving them.

2.5 GHG Inventory Boundaries

2.5.1 Geographic Boundary

The geographic scope of the emissions report determines which emissions are accounted for and reported by the City. The City operations are conducted within the City municipal boundary; the City does not control or operates any facility outside such geographic boundary.

2.5.2 Organizational Boundaries

Organizational boundaries define the limits of a GHG inventory by identifying the activities that are owned and/or controlled by the entity and determining which emission sources should be included in its GHG inventory. As recommended by the LGOP, the GHG emissions contained in this report were consolidated according to the Operational Control approach. The operational control is established for facilities, activities, and sources over which the City possesses the authority to implement operating policies such as financial, environmental, health, or safety directives. A description of the facilities and sources included in the City's Operational Control boundary is provided in the following paragraph, further detailed according to the Operational Boundary described in the next paragraph.

2.5.3 Operational Boundaries

Operational boundaries in GHG inventory identifies the specific types of emission sources that the City, as defined by the inventory's organizational boundaries, includes in its GHG Inventory. A key distinction in setting operational boundaries is whether GHG emissions sources are categorized as direct emissions or indirect emissions.

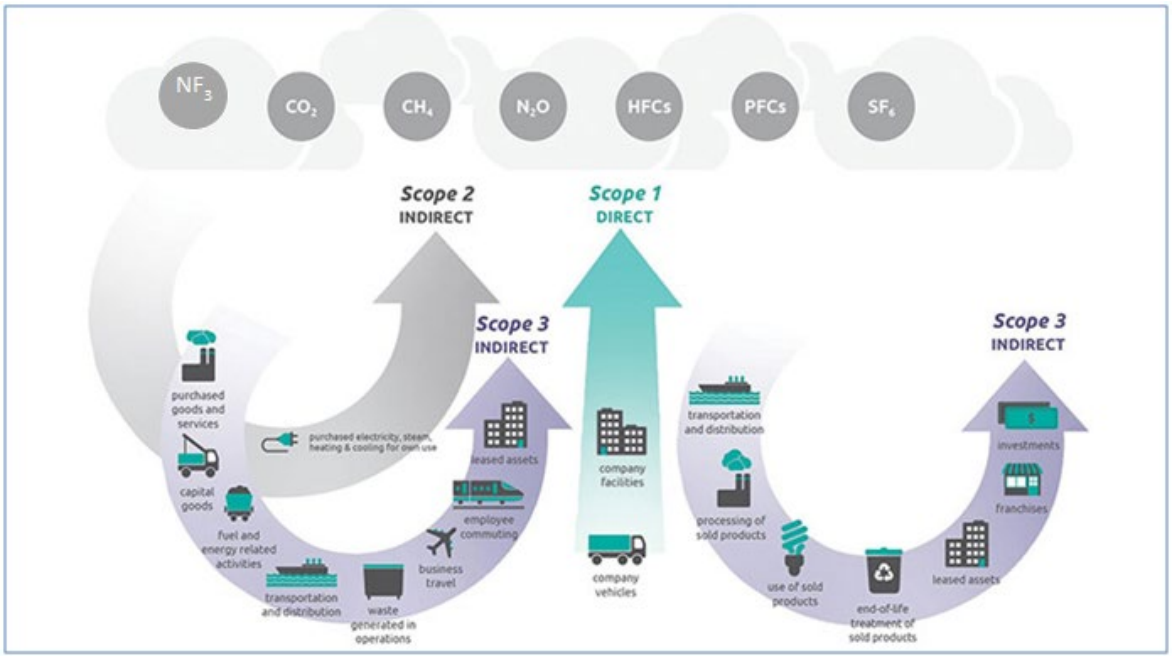
- Direct emissions (Scope 1): result from emission sources that are owned or operated by the organization.
- Indirect emissions (Scope 2, Scope 3): emissions that are due to an organization's activities but occur from sources owned or controlled by another organization.

The concept of emission "scopes" expands upon the distinction between direct and indirect emissions, splitting indirect emissions into two separate categories: Scope 2, associated with indirect energy emissions such as those due to electricity purchased from a utility; Scope 3, capturing all other types of indirect emissions such as employee commuting, disposal of waste generated, etc. Due to the complexity of determining them, Scope 3 emissions are not included in this GHG inventory.

In addition, categories of common sources, such as stationary combustion, mobile combustions, fugitive emissions, etc., create a framework for the organization of the inventory. This framework facilitates the identification of appropriate quantification methodologies for emission sources, collection of data, as well as reporting of inventory results.

The following diagram provides a summary of the scopes and categories of emissions across the value chain of a reporting entity, as defined in the WRI GHG Protocol.

Figure 4: Overview of GHG Protocol Scopes and Emissions Across the Value Chain



Source: GHG Protocol - Scope 3 Corporate Value Chain Accounting Reporting Standard_041613 (WRI, WBCSD)

The general operational boundaries of the City GHG inventory are as follows:

Scope 1: Direct GHG emissions from activities that are owned or controlled by the reporting entity.

The City Scope 1 GHG emission categories include the following:

- stationary combustion,
- mobile combustion,
- fugitive emissions.

Scope 2: Indirect GHG emissions from the generation of purchased or acquired energy, such as electricity, which is consumed by the reporting entity.

The City Scope 2 GHG emission categories include the following:

- purchased electricity.

Scope 3: All other indirect emissions not covered in Scope 2. Not included in this report

The complete list of emission sources in the City GHG inventory are listed in the following tables, organized by Scope and Sector.

2.6 Scope 1 - Direct Emissions

The following sectors were identified as Scope 1 sources of GHG emissions:

Table 5: Scope 1 Emission Sources

Sector	Emission Category
Fleet Vehicle Emissions	Mobile Fuel Combustion
Public Transit Emissions	Mobile Fuel Combustion
Buildings and Facilities	Stationary Fuel Combustion

A detailed breakdown of the Scope 1 specific sources is provided in the following paragraphs.

2.7 Scope 2 - Energy Indirect Emissions

The following sectors were identified as Scope 2 sources of GHG emissions.

Table 6: Scope 2 Emissions Sources

Sector	Emission Category
Buildings and Facilities	Emissions from Grid Electricity
Street Lights and Traffic Signals	Emissions from Grid Electricity

A detailed breakdown of the Scope 2 specific sources is provided in the following paragraphs.

2.8 GHG Inventory Exceptions

Fugitive emissions from refrigerants and (HFCs, PFCs, NF_3, or SF_6) were not quantified for the City GHG inventory due to the absence of records and information on air conditioning and refrigeration equipment inventory or service and maintenance. This is an area that should be improved for future GHG inventories efforts by the City.

2.9 Inventory Data Collection Methodologies

The primary methodologies utilized to collect data were the following:

- Data and information were provided by the City staff.
- Energy consumption data were provided by the utility supplying the City, upon authorization by the City.
- In some cases when data were not available for a particular source, individuals with knowledge of the activities provided an estimate based on experience.

The collection methodology for each source is summarized below.

2.10 Scope 1 Emissions

2.10.1 Stationary Combustion

The City provided an inventory of the buildings and facilities owned and or operated by the City. Each building and facility in the inventory was confirmed as being under the City operational control and the associated fuel and electricity consumption were included in the inventory.

2.10.1.1 Natural Gas

The City staff provided the list of natural gas utility accounts for each building and service address and the bills for the consumption for year 2017, quantified in therms. The fuel usage data was checked against the accounting records provided by PSE&G and the total natural gas usage for each City-controlled building was calculated. Where appropriate, buildings and facilities were aggregated according to the City department that utilizes them. The applicable emissions quantification methodology from the LGOP was applied to these fuel values as described in the next paragraphs.

Sources of Emissions from Stationary Fuel Combustion	Fuel
Hoboken Parking Utility	Natural Gas
Environmental Services Department	
City Hall	
Public Library	
Police Headquarter	
Boys and Girls Club	
Fire Department	
Human Services Department	
Volunteer Ambulance Corps	
Transportation & Parking Department	

2.10.2 Mobile Combustion – Gasoline and Diesel

The City provided an up-to-date inventory of all the vehicles owned and operated by the various City departments. The fleet includes various types of vehicles, such as passenger cars, light and heavy trucks, and off-road vehicles for road maintenance. The fleet inventory did not include sufficient data on vehicle age and odometer readings; therefore, the annual mileage driven by each vehicle was estimated based on fuel usage data.

All the fleet vehicles were aggregated by department and by fuel as listed in the table below:

Mobile Combustion Sources-Fuel
Administration - Gasoline
Ambulance Corps Fleet - Diesel
Ambulance Corps Fleet - Gasoline
Buildings - Gasoline
Community Development - Gasoline
Environmental Services - Diesel
Environmental Services - Gasoline
Fire Dept. Fleet - Diesel

Mobile Combustion Sources-Fuel
Fire Dept. Fleet - Gasoline
Hoboken Parking Unit Fleet - Diesel
Hoboken Parking Unit Fleet - Gasoline
Human Services - Diesel
Human Services - Gasoline
Police Fleet - Diesel
Police Fleet - Gasoline
Transportation & Parking - Gasoline
HOP Public Transit - Gasoline

The entire City's fleet is fueled at public gas stations by using city-issued fuel cards. The City provided fuel card records for the entire calendar year 2017 that identify the type of fuel, the employee fueling the vehicle, and the department he or she belongs to. The total volume of gasoline or diesel used by each department was then used to estimate the total VMT for all the vehicles used by that department. This was necessary due to the absence of detailed odometer readings or mileage records for each vehicle.

2.10.3 Fugitive Emissions

First Environment was unable to obtain sufficient information regarding the possible sources of fugitive emissions such as air conditioning equipment or certain type of fire extinguishing systems. As such it was decided to not include these sources for emission year 2017.

2.11 Scope 2 Emissions

2.11.1 Purchased Electricity

The City staff provided all the utility invoices for year 2017 electricity consumption by City buildings, street lighting and traffic signals. The total electricity consumption was calculated by aggregating the invoices for each electrical service account, prorated as required for the months of January and December. The appropriate GHG emissions quantification methodology was applied to the annual totals for each account.

2.12 Scope 3 Emissions

On accordance with LGOP, these are not mandatory and therefore not included in the 2017 GHG inventory for the municipal operations.

3. Emissions Quantification Methodologies

GHG emissions are calculated applying the appropriate methodologies from:

- ICLEI's Local Government Operations Protocol (LGOP), Version 1.1, May 2010.

In addition, GHG emissions are calculated using emission factors (EF) sourced from:

- US EPA Center for Corporate Climate Leadership - Emission Factors for Greenhouse Gas Inventories – March 9, 2018;
- US EPA Emissions & Generation Resource Integrated Database - eGRID2016;
- Fifth Assessment Report of the Intergovernmental Panel on Climate Change - IPCC AR5.

The GHG emissions quantification was performed by ICLEI's ClearPath Pro Tool, which includes the algorithms calculating the emission according to LGOP methods.

The quantification methodology for each source is summarized in the following paragraphs.

3.1 Scope 1 Emissions

3.1.1 Stationary Combustion – Natural Gas

Emissions were calculated according to Equations 6.2, 6.3 and 6.5 of LGOP by multiplying the total gallons of natural gas usage by stationary sources by the appropriate CO_2, CH_4, and N_2O emission factors sourced from US EPA emission factors for GHG inventories. The results of these calculations in metric tonnes of CO_2, CH_4, and N_2O emissions were converted to metric tonnes of CO_2e by using Equation 6.7 of the LGOP and applying the appropriate GWP factor for each GHG from IPCC AR5.

3.1.2 Mobile Combustion

3.1.2.1 Gasoline

GHG emissions were calculated according to Equation 7.2, of LGOP by multiplying the total gallons of gasoline usage for mobile sources by the appropriate CO_2 emission factor sourced from the US EPA emission factors for GHG inventories. Emissions of CH_4, and N_2O were calculated according to Equations 7.6 and 7.7 of LGOP by multiplying the estimated mileage driven by the vehicles in each fleet category for the appropriate CH_4, and N_2O emission factors sourced from the US EPA emission factors for GHG inventories.

The results of these calculations in metric tonnes of CO_2, CH_4, and N_2O emissions were converted to metric tonnes of CO_2e by applying Equation 7.8 of the LGOP using the appropriate GWP factor for each GHG from IPCC AR5.

3.1.2.2 Diesel

GHG emissions were calculated according to Equation 7.2 of LGOP by multiplying the total gallons of diesel usage for mobile sources by the appropriate CO_2 emission factor sourced from the US EPA emission factors for GHG inventories. Emissions of CH_4, and N_2O were calculated according to Equations 7.6 and 7.7 of LGOP by multiplying the estimated mileage driven by the vehicles in each fleet category for the appropriate CH_4, and N_2O emission factors sourced from the US EPA emission factors for GHG inventories.

The results of these calculations in metric tonnes of CO_2, CH_4, and N_2O emissions were converted to metric tonnes of CO_2e by applying Equation 7.8 of the LGOP using the appropriate GWP factor for each GHG from IPCC AR5.

3.2 Scope 2 Emissions

3.2.1 Purchased Electricity

Location-based electricity GHG emissions were calculated according to Equation 6.10 and 6.11 of the LGOP by multiplying the total electricity consumption in MWh by City-controlled buildings, street lighting, and traffic signals for the appropriate CO_2, CH_4, and N_2O electricity emission factors for the New Jersey region (RFC East) sourced from the US EPA eGRID 2016 database[2].

eGRID subregion acronym	eGRID subregion name	Total output emission rates (lb/MWh)		
		CO_2	CH_4	N_2O
RFCE	RFC East	758.2	0.050	0.009

The results of these calculations in metric tonnes of CO_2, CH_4, and N_2O emissions were converted to metric tonnes of CO_2e by multiplying for the appropriate IPCC AR5 GWP factor for each GHG.

An equivalent calculation was performed to quantify "market-based electricity emissions." Because the City does not make use of any direct supply of electricity from dedicated sources or of any contractual instruments that would convey specific emissions rates for the purchased electricity, the market-based electricity GHG emissions are equivalent to the location-based electricity GHG emissions.

3.3 Scope 3 Emissions

Scope 3 GHG emissions from City operations were not accounted for and are not included in this Inventory.

3.4 Global Warming Potentials

The Global Warming Potentials, identified in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, were used to convert the GHG emissions associated with Airport activities into carbon dioxide equivalents (CO_2e).

The Global Warming Potentials applied to the City GHG inventory are the following:

Name	Chemical Formula	SAR GWP Value
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

[2] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

3.5 Quantification of Emissions

3.5.1 Scope 1 GHG Emissions

The City Total Scope 1 Emissions were quantified as 1,853 tCO_2e, including the following specific GHG contributions:

Table 7: Scope 1 GHG Emissions

Greenhouse Gas	t GHG	t CO2e
Carbon Dioxide (CO_2)	1,847.49	1,847.49
Methane (CH_4)	0.0938	2.62
Nitrous Oxide (N_2O)	0.0098	2.60
Total		1,852.72

The distribution of Scope 1 emissions by sector is shown in percentage and in tCO_2e in the charts below.

Figure 5: Scope 1 Emissions by Sector, in Percentage

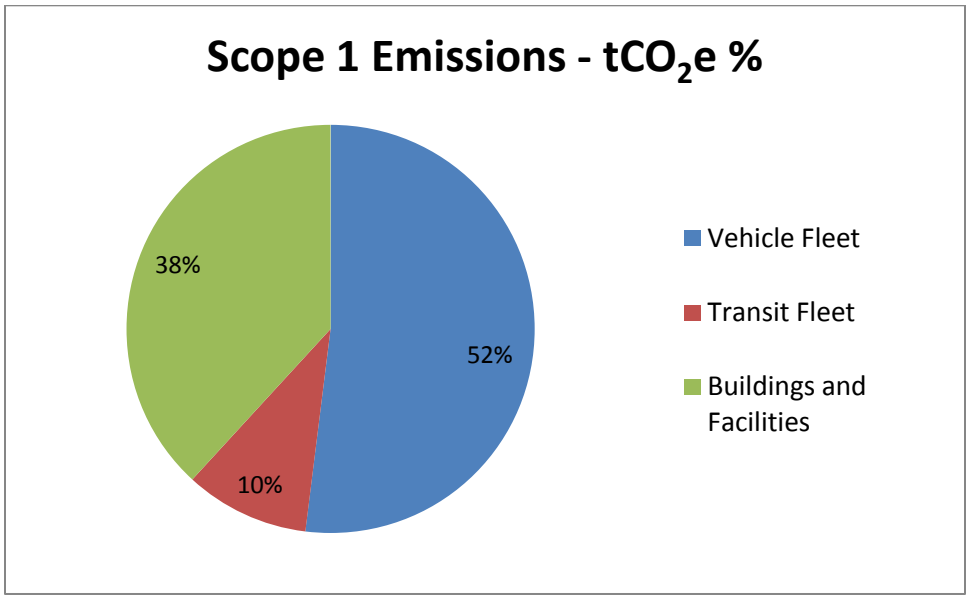
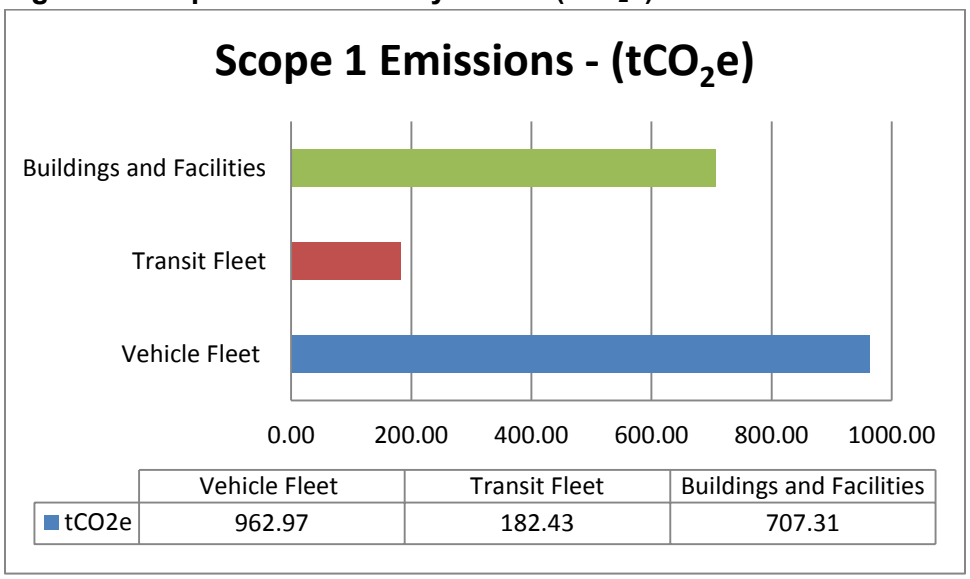


Figure 6: Scope 1 Emissions by Sector (tCO_2e)



The results highlight the predominance of the vehicle fleet as the major source of GHG emissions. Scope 1 emissions (stationary fuel combustion) from buildings and facilities rank as the second largest source followed by a lower amount of emissions from the transit fleet operated by the City.

The following sections detail the sources of GHG emissions in each sector, identifying the contribution by each fuel, or refrigerant GHG for the fugitive emission.

3.5.2 Direct Stationary Combustion Emissions – Building and Facilities

The City's direct stationary combustion emissions were quantified as 707.31 tCO_2e. This stationary combustion quantity includes contributions only from natural gas:

Table 8: Direct Stationary Combustion by Fuel

Stationary Combustion Emissions	tCO_2e
Natural Gas	707.31
Total	**707.31**

3.5.3 Direct Mobile Combustion Emissions – Vehicle Fleet

The direct mobile combustion emissions by the City Vehicle Fleet were quantified as 962.97 tCO_2e. This mobile combustion quantity includes contributions from the following fuels:

Table 9: Direct Mobile Combustion Emissions by Fuel – Vehicle Fleet

Mobile Combustion Emissions – Vehicle Fleet	
Fuel	tCO_2e
Gasoline	716.18
Diesel	246.79
Total	**962.97**

3.5.4 Direct Mobile Combustion Emissions – Transit Fleet

The City Transit Fleet mobile combustion emissions were quantified as 182.43 tCO_2e. The mobile combustion emissions include contributions from gasoline only.

Table 10: Direct Mobile Combustion Emissions by Fuel – City Transit Fleet

Mobile Combustion Emissions – City Transit Fleet	
Fuel	tCO_2e
Gasoline	182.43
Total	**182.43**

3.5.4.1 Scope 1 Emissions by Source

The following tables and chart show the Scope 1 emissions from each specific source, as identified in the inventory. For simplicity, sources are separated according to mobile and stationary combustion. For each source, the energy usage responsible for the emissions is also reported, expressed in volume of fuel combusted.

Table 11: Scope 1 – Mobile Combustion Emissions by Source (tCO_2)

Source	Fuel Use (Gal)	Fleet VMT (miles)	GHG Emissions (tCO_2e)
Ambulance Corps Fleet - Gasoline	5,557	77,793	48.96
Ambulance Corps Fleet - Diesel	1,158	9,262	11.83
Fire Dept. Fleet - Gasoline	5,822	81,507	51.26
Fire Dept. Fleet - Diesel	9,774	78,192	99.90
Hoboken Parking Unit Fleet - Gasoline	19,255	269,575	169.47
Police Fleet - Gasoline	31,438	440,134	276.67
Environmental Services - Diesel	13,084	104,673	133.74
Environmental Services - Gasoline	10,655	149,166	93.80
Buildings - Gasoline	292	4,081	2.57
Transportation & Parking - Gasoline	724	10,141	6.37
Administration - Gasoline	1,248	17,472	10.99
Human Services - Gasoline	6,326	88,568	55.69
Hoboken Parking Unit Fleet - Diesel	85	680	0.87
Police Fleet - Diesel	14	111	0.14
Community Development - Gasoline	45	630	0.40

Source	Fuel Use (Gal)	Fleet VMT (miles)	GHG Emissions (tCO_2e)
Human Services - Diesel	31	247	0.32
Transit Fleet - Gasoline	20,672	206,719	182.43
Total	**126,180**	**1,538,951**	**253.97**

Table 12: Scope 1 – Stationary Combustion Emissions by Source (tCO_2)

Source	Energy Use (Therms)	GHG Emissions (tCO_2e)
Hoboken Parking Unit - Natural Gas	12,718	67.64
Environmental Services Dept. - Natural Gas	9,460	50.31
City Hall - Natural Gas	19,055	101.35
Public Library - Natural Gas	10,027	53.33
Police Headquarter - Natural Gas	10,536	56.04
Boys and Girls Club - Natural Gas	983	5.23
Fire Department - Natural Gas	17,880	95.10
Human Services Dept. - Natural Gas	37,363	198.72
Volunteer Ambulance Corps - Natural Gas	2,247	11.95
Transportation & Parking Dept. - Natural Gas	12,718	67.64
Total	**132,987**	**707**

The same results displayed in bar diagrams:

Figure 7: Scope 1 Mobile Emission by Source (tCO_2e)

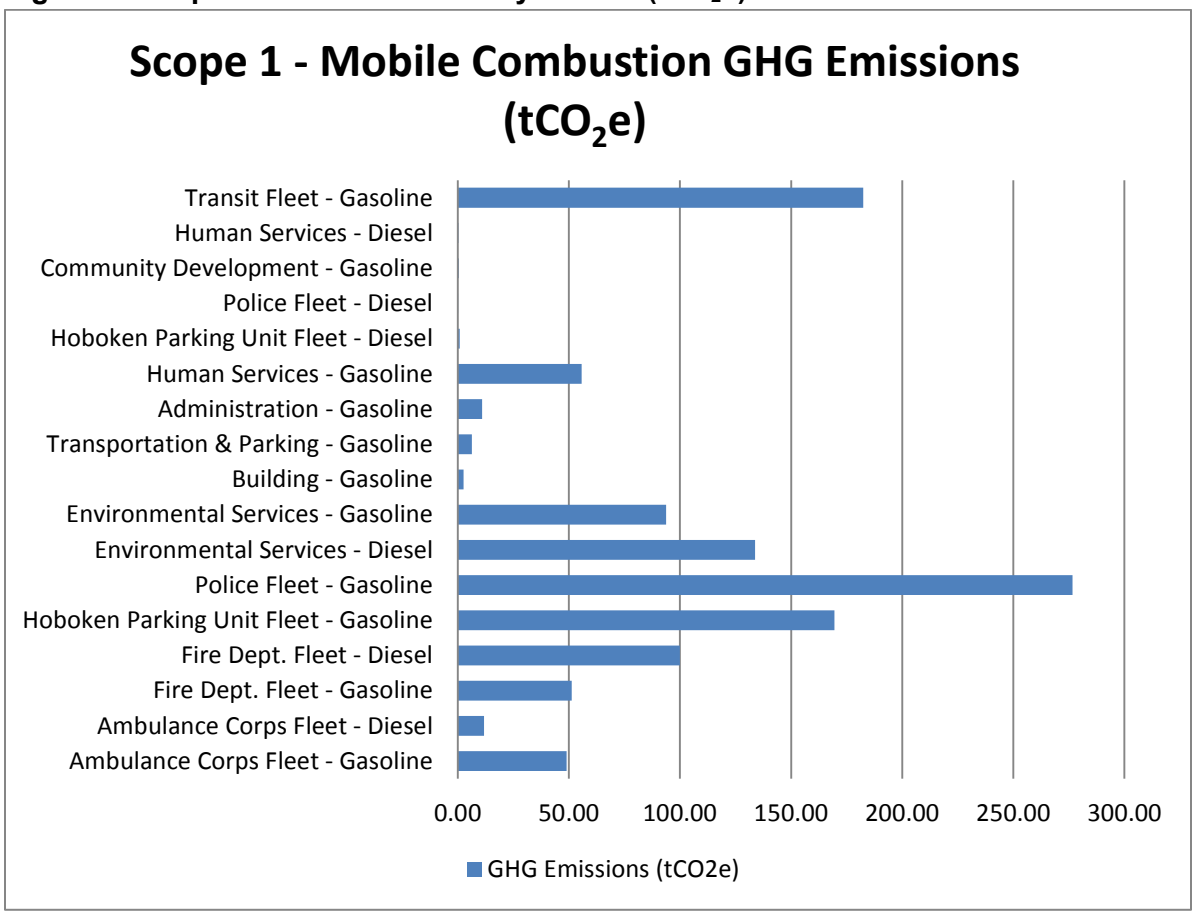
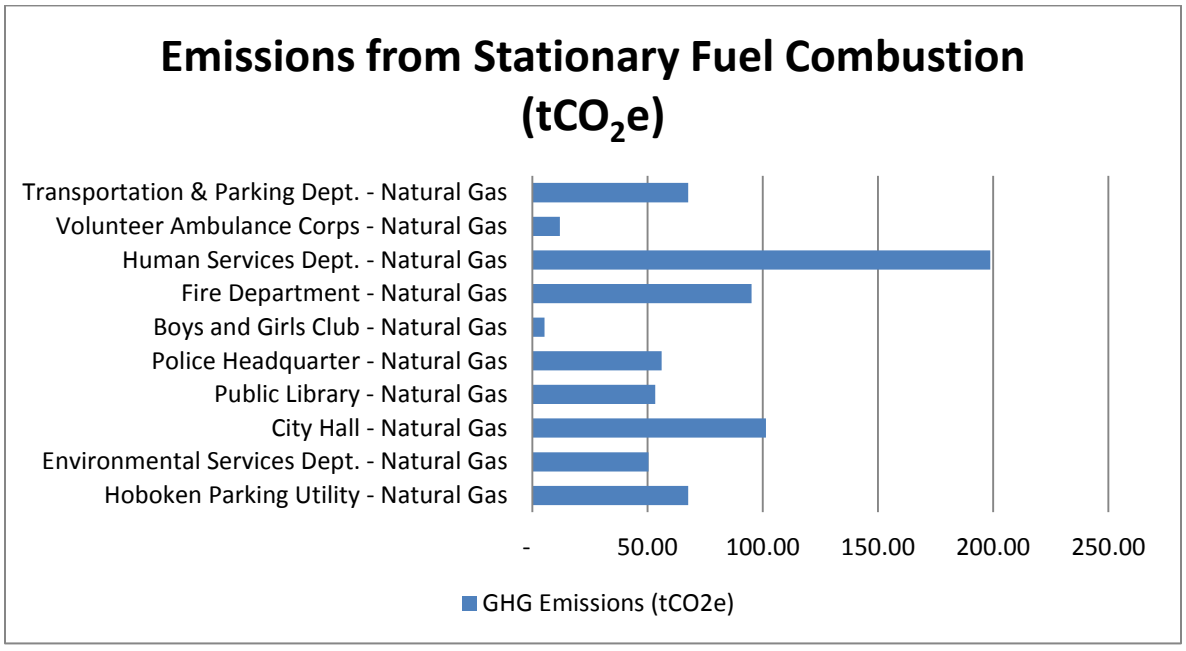


Figure 8: Scope 1 Stationary Emission by Source (tCO_2e)



For fleet emissions, the detailed breakdown by sources indicates the police, public transit, and parking unit fleets as generating the largest shares of emissions. The result is not surprising considering that these are the fleets with the largest VMT by the vehicles.

For stationary emissions, the human services department (mostly located in the multi-service building), and the City Hall are the largest sources of emissions. These are some of the largest buildings (excluding the parking garages) operated by the City and as expected are generating the largest shares of emissions from stationary combustion.

3.6 Scope 2 GHG Emissions – Purchased Electricity

All Scope 2 emissions reported are from purchased electricity. Total Scope 2 Emissions were quantified as 2,406.99 metric tonnes t CO_2e, including contributions of the following GHGs:

Table 13: Scope 2 GHG Emissions

Greenhouse Gas	t GHG	t CO_2e
Carbon Dioxide (CO_2)	2,406.98	2,406.98
Methane (CH_4)	0.00016	0.0044
Nitrous Oxide (N_2O)	0.00003	0.0076
	Total	**2,406.99**

The distribution of Scope 2 emissions by sector is shown in percentage and in tCO_2e in the charts below.

Figure 9: Scope 2 Emissions by Sector, in Percentage

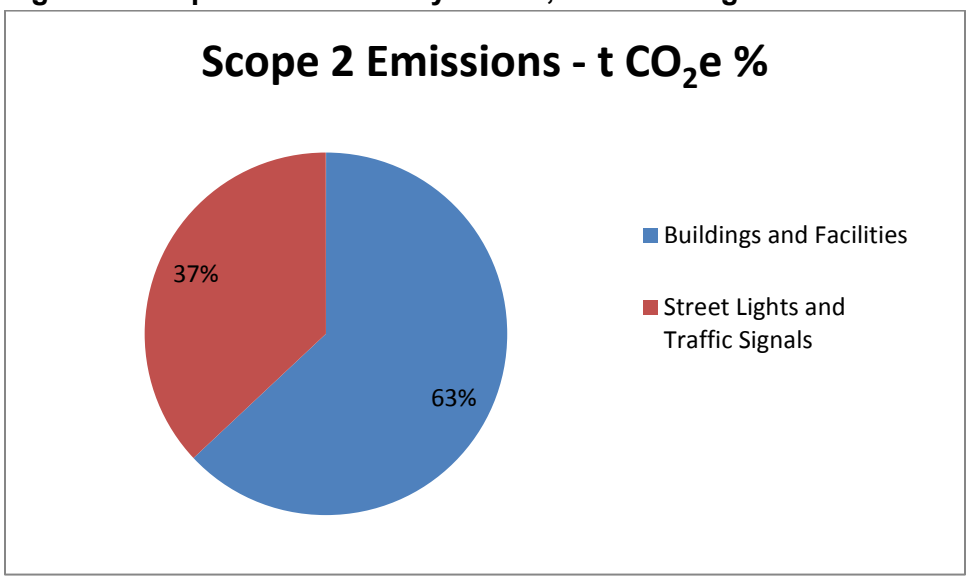
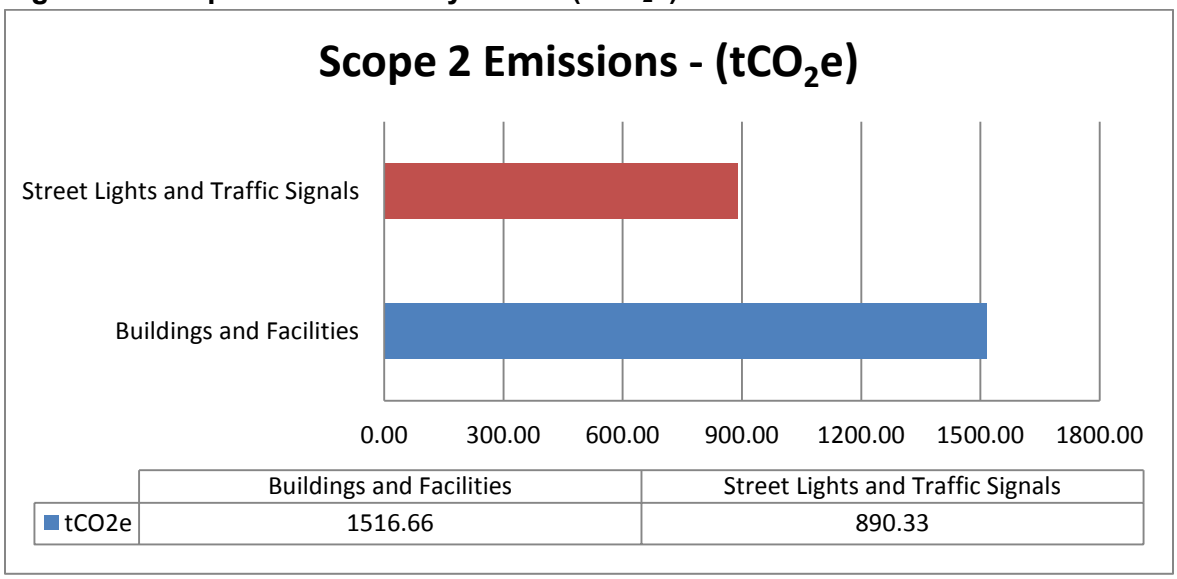


Figure 10: Scope 2 Emissions by Sector (t CO_2e)



The results indicate that electricity consumption by streetlights is higher than that by buildings and facilities (which also include lighting for the park and ball park facilities).

3.6.1.1 Scope 2 Emissions by Source

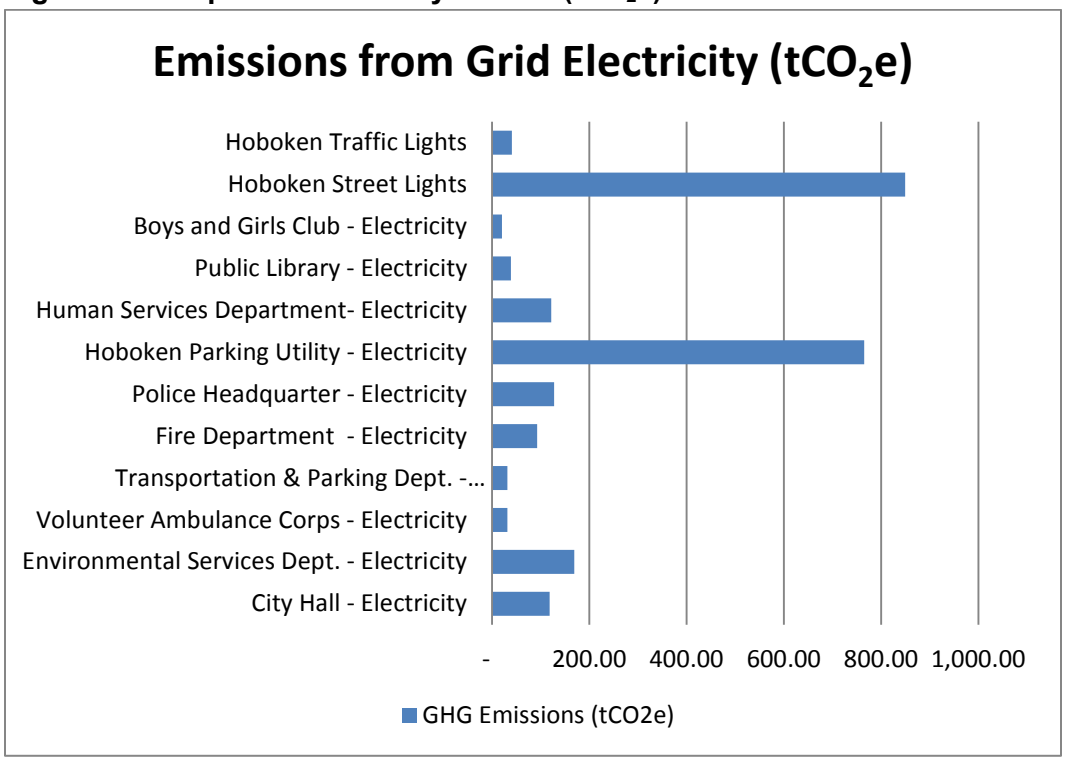
The following table and chart show the Scope 2 emissions from each specific source, as identified in the inventory. For each source, the energy usage responsible for the emissions is also reported, expressed in kWh of electricity used.

Table 14: Scope 2 Emissions by Source (tCO_2)

Source	Energy Use (kWh)	GHG Emissions (tCO_2e)
City Hall - Electricity	344,872	118.60
Environmental Services Dept. - Electricity	491,864	169.15
Volunteer Ambulance Corps - Electricity	91,348	31.42
Transportation & Parking Dept. - Electricity	91,311	31.40
Fire Department - Electricity	268,806	92.44
Police Headquarter - Electricity	371,248	127.67
Hoboken Parking Utility - Electricity	2,224,503	765.02
Human Services Department- Electricity	354,712	121.99
Public Library - Electricity	112,800	38.79
Boys and Girls Club - Electricity	58,640	20.17
Hoboken Street Lights	2,470,506	849.62
Hoboken Traffic Lights	118,364	40.71
Total (kWh - tCO_2e)	**6,998,974**	**2,407**

The same results displayed in a bar diagram:

Figure 11: Scope 2 Emission by Source (tCO_2e)



The results show that street lights and the parking utility buildings are responsible for the majority of the Scope 2 emissions, followed by the City Hall, Environmental Services, and Human Services departments. Besides the street lights, the parking utility consumption is also due almost entirely to lighting equipment and the immediate conclusion is that actions to reduce GHG emissions should prioritize the reduction of energy consumption by lighting equipment.

3.7 Scope 2 Emission: Location-based vs. Market-based approach

The City's reported emissions from purchased electricity were calculated using a location-based method by applying the grid emissions factor from the US EPA eGRID emission factor for the RFCE sub-region. The current version of the LGOP, published in 2010, does not require separately quantifying the Scope 2 emissions according to location-based and the market-based approach. Nonetheless this requirement has become common in GHG inventory protocols issues or updated after 2014; therefore, we are including a brief discussion of the quantification approach applied for this inventory.

The City does not use any direct supply of electricity from dedicated sources, neither any contractual instrument that would convey specific emissions rates for the purchased electricity. Therefore, applying the market-based method emission factors hierarchy from WRI's GHG Protocol Scope 2 Guidance, leads to the conclusion that the market-based method emission factor is equivalent to the location-based factor.

The table below provides a comparison of the market-based and location-based method emission factors and the resulting GHG emissions from these different approaches, which in the case of the City of Hoboken, are identical:

Table 15: Location-based and Market-based and EFs and GHG Emissions

Location-based Method			
RFCE Emission Factors	$lbCO_2$/MWh	$lbCH_4$ /GWh	lbN_2O /GWh
	758.2	0.050	0.009
Emissions	CO_2 (tCO_2e)	CH_4 (tCO_2e)	N_2O (tCO_2e)
	2,406.98	0.00444	0.00757
Market-based Method			
RFCE Emission Factors	$lbCO_2$/MWh	$lbCH_4$ /GWh	lbN_2O /GWh
	758.2	0.050	0.009
Emissions	CO_2 (tCO_2e)	CH_4 (tCO_2e)	N_2O (tCO_2e)
	2,406.98	0.00444	0.00757

4. GHG Inventory Base Year

The GHG inventory base year provides a standardized point of reference against which future inventories can be compared to identify changes, such as reductions, or track progress toward an emission goal or action plan. The City has selected year 2017 as the GHG inventory base year.

Once the Base Year has been selected, the next step is to select one or several future years by which the City wishes to reach certain emissions reduction goals.

5. GHG Emission Reduction Goals

As described in more detail in the Climate Action Plan, the City of Hoboken joined the Sustainable Jersey program in 2010; just one year after the program was established. The City received Bronze certification from Sustainable Jersey in 2011, was recertified in 2014, and received the Silver certification in 2017. Hoboken has decided to pursue the Sustainable Jersey Gold Star in Energy certification, which further affirms their commitment to sustainability, and specifically, mitigation efforts. As such, the City has selected to establish GHG reduction goals in line with the Sustainable Jersey Gold Star targets which require the City to demonstrate at least 3.6 percent annual reductions in municipal GHG emissions and 1 percent annual reductions in community GHG emissions over the base year.

In accordance with these requirements, the City set two reduction goals at one year and three years from the base year (3.6 percent and 10.8 percent, respectively), but it also added the goals of achieving net-zero GHG emissions for municipal operations by 2022 and exceeding the Paris Agreement target[3] by becoming carbon neutral by 2027.

Because the inventory is completed in 2018 based on 2017 year activity data, we assume that the first year of implementation would end in 2019, the third year would be the end of 2021, and the municipality will achieve carbon neutrality by the end of 2027, or year nine of the climate actions implementation.

The table below shows the reductions goals of 3.6 percent by the end of 2019, 10.8 percent by 2021, and the equivalent amount in tCO2e required to achieve the goals.

In summary, the proposed emission reduction goals are the following:

Table 16: Emission Reduction Goals and Targets

Target	Target Year	Reduction Goal from 2017 Base Year GHG Inventory (%)	Reduction Goal from 2017 Base Year GHG Inventory (tCO_2e)
Year 1	2019	3.6%	153
Year 3	2021	10.8%	460
Year 4	2022	Net Zero	Obtain all municipal electricity from renewable sources
Year 9	2027	Carbon Neutral	Maximize the GHG reduction and offset the remaining emissions

[3] U.S. commitment: 26%-28% below 2005 level by 2025

6. GHG Emission Reduction Measures

In order to achieve the reduction goals described in the previous paragraph the City must identify a series of GHG emission reduction measures tailored at achieving such goals within the established timeline. The analysis of the City energy consumption and emission sources performed to conduct the GHG inventory provides a basis to conduct an informed selection of potential emission reduction measures. These will have to be compatible with the City operations, target as much as possible the largest sources of emissions where the largest reductions could be achieved, all this while balancing budget constraints and achieving the best balance between cost and benefits.

In addition, as discussed in the City's Climate Action Plan, the selected measures should be in line with the requirements of the Sustainable Jersey program, maximizing the points earned to achieve registration.

The review of the Scope 1 and Scope 2 emissions inventory results included in the previous paragraphs highlighted that the largest contributions were identifiable in the electricity consumption by the street lights and parking facilities, and the fuel consumption by the vehicle fleets. These are followed by emissions from stationary fuel combustion and electricity consumption in buildings.

Based on this analysis and on the experience garnered from reviewing case studies for similar municipalities, these are the possible emission reduction measures identified for discussion:

Table 17: GHG Emissions Reduction Measures – Municipal Operations

Emission Reduction Measure	Target Scope and Sector	Sustainable Jersey Action
Renewable Power Purchase Agreement	Scope 2 – Electricity in Buildings	No
Install photovoltaic solar energy systems on City buildings	Scope 2 – Electricity in Buildings	Yes
Implement Energy Efficiency Upgrades at City Hall	Scope 2 – Electricity in Buildings Scope 1 – Stationary Combustion in Buildings	Yes
Conduct energy audits and implement Energy Efficiency Upgrades at other City facilities.	Scope 2 – Electricity in Buildings Scope 1 – Stationary Combustion in Buildings	Yes
Install LED street lamps	Scope 2 – Electricity in Street Lights	No
Phase in hybrid electric and electric vehicles into the City's vehicle fleet.	Scope 1 – Mobile Combustion	Yes
Phase in low-emission buses into the City's Public Transit fleet.	Scope 1 – Mobile Combustion	Yes

Each one of these measures was modeled in ClearPath to quantify potential emissions reductions as well as to estimate implementation cost, based on either ClearPath default

information or appropriate reference data sourced from literature. ClearPath also tracks the potential emission reductions achievable by each measure during the 2019-2028 period, allowing developing the best implementation strategy to maximize the benefits while distributing the costs of deploying each measure over the target period.

6.1 Renewable Power Purchase Agreement

The action recommends the adoption of a policy requiring the use of renewable energy to meet the City's government operation demand. This measure is not included in the Sustainable Jersey list of priority climate actions but it would nonetheless allow for a significant reduction of the City's GHG emissions.

The policy should include a commitment to allocate funding for the purchase of renewable energy, renewable energy credits (RECs), and/or the installation of renewable energy systems; the last item is discussed as a separate climate action. For this action we are focusing on the City's purchase of an increasing share of their annual electricity consumption from a renewable energy provider. This can be achieved by establishing a power purchase agreement (PPA) directly with a renewable power plant, such as a solar photovoltaic (PV) plant or a wind energy farm, or otherwise through the utility serving the City or a renewable energy marketer. In general, at current market conditions, the renewable energy PPA requires the payment of a premium per each unit of electricity delivered and as such this action would not provide a potential for energy cost savings, at least in the short term. ClearPath does not provide a default cost per kWh for procuring renewable electricity, but it was estimated that the electricity consumption rate increase could be as much as $0.01 per kWh.

For the emissions estimate in ClearPath, we assumed that the City procures a share of their annual consumption (6.5 percent for 2019 and 2020), sufficient to cover the annual reduction goal (3.6 percent per year). The share increases to 19.5 percent of the annual electricity consumption by 2021 and up to 100 percent from 2025 onwards.

The table below shows the estimate of GHG reduction and costs based on the baseline year electricity consumption. The costs will actually be lower in the future years if other climate action measures are implemented and the overall electricity consumption is gradually reduced.

Renewable Energy Purchase (% Baseline Electricity/Year)	Renewable Energy Purchase (kWh/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost ($/year)
6.5%	455,000	-156	$4,555
19.5%	1,364,800	-470	$13,648
100%	6,998,974	-2,407	$70,000

6.2 Solar Photovoltaic Energy System Installation

This energy reduction measure requires the installation of solar PV energy production systems on the suitable City buildings. ClearPath provides an estimate of the potential savings according to installed capacity and generation efficiency, the latter dependent on the geographic location of the system. The potential square footage available for the installation was conservatively estimated by assuming 50 percent of the rooftop area of the major parking facilities operated by the City could be utilized. This resulted in approximately 50,000 sqft of solar installation. This data was entered in the National Renewable Energy Laboratory (NREL) PVWatts Calculator to estimate the capacity installed and the generation efficiency that could be

achieved. According to the calculator, the electricity production capacity could be 500 kW with an expected output of 650,000 kWh/year. An estimate of the implementation cost is not provided by ClearPath, but it was budgeted based on market data at $5,000/kW installed. The measure would yield potential energy cost savings of $45,000/year and reduce the GHG emission by 5.3 percent year from the baseline, or approximately 224 tCO_2e/year. The overall benefits in terms of GHG Inventory are estimated at 2-3 tCO_2e/year.

Change Electricity Use (kWh/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost	Electricity Savings ($/Year)
-650,000	-224	$2,500,000	$45,500

6.3 City Hall Retrofit - Energy Efficiency

The City is in the process of implementing a series of building energy efficiency retrofits in conjunction with the Direct Install initiative under the New Jersey's Clean Energy Program (NJCEP) by the New Jersey Board of Public Utilities (NJBOP). The Direct Install program provides funding to implement energy efficiency upgrades for local governments.

This measure includes improvements to the City Hall building's heating, air conditioning and electrical equipment. Heating, ventilation, and air conditioning (HVAC) equipment represents 30 to 40 percent of commercial building energy use. This measure is consistent with Sustainable Jersey priority climate actions for Gold Star certification. According to documents provided by the City, the Direct Install measures planned for the City Hall building will deliver annual savings of 64,500 kWh/year for electricity and 1,200 therms/year for natural gas consumption.

By using the ClearPath calculator and applying the actual Direct Install energy saving estimates in lieu of ClearPath's default factors, the annual GHG emission reduction was estimated at approximately 28 tCO_2e/year.

Change Electricity Use (kWh/Year)	Change Heating Fuel Use (MMBtu/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost	Electricity Savings ($/Year)	Heating Fuel Savings ($/Year)
-64,451	-1,200	-28	$15,800	$12,800	$944

The cost estimate is based on the final cost provided by the City after accounting for the Direct Install benefits. This measure was conducted not only for the City Hall building but also extended to other City facilities, potentially increasing the energy and emission reductions, as discussed in the next section.

6.4 City Buildings Retrofit - Energy Efficiency

As mentioned in the previous paragraph, the City is in the process of implementing a series of building energy efficiency retrofits in conjunction with the Direct Install initiative under the NJBOP-NJCEP program, providing funding to implement energy efficiency upgrades for local governments.

This energy efficiency measure includes improvements to the several City building's heating, air conditioning and electrical equipment. In addition, it includes the conversion to LED for the lighting system in the City's parking garage facilities. This combination of measures is consistent with Sustainable Jersey priority climate actions for Gold Star certification. According

to documents provided by the City, the Direct Install measures planned for the City buildings will deliver an overall annual savings of 615,570 kWh/year for electricity and 5,550 therms/year for natural gas consumption.

By using the ClearPath calculator and applying the actual Direct Install energy saving estimates in lieu of ClearPath's default factors, the annual GHG emission reduction was estimated at approximately 242 tCO_2e/year.

Change Electricity Use (kWh/Year)	Change Heating Fuel Use (MMBtu/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost	Electricity Savings ($/Year)	Heating Fuel Savings ($/Year)
-615,570	-5,550	-242	$78,900	$90,900	$4,560

The cost estimate is based on the final cost estimates provided by the City after the Direct Install benefits are accounted for. A summary table with the measures aggregated by City department is included below:

Department/Facility	Direct Install Final Cost after Subsidy	kWh Saving	Therms Saving	Cost Saving Annual Electric	Cost Saving Annual Gas
Hoboken Volunteer Ambulance Corps	$2,000	18,400	570	$2,730	$244
Fire Department	$27,385	125,635	3,471	$20,457	$2,905
Hoboken Public Library	$7,000	62,000	359	$8,700	$350
Hoboken Parking Utility	$37,236	400,880	-	$57,814	-
Environmental Services Department, Transportation & Parking Department	$5,300	8,655	1,152	$1,200	$1,060
Total	**$78,921**	**615,570**	**5,552**	**$90,901**	**$4,559**

6.5 Street Lights Conversion to LED

This measure consists of upgrading the street lights within the City boundary to advanced street light technology such as light-emitting diodes (LEDs). The conversion to LED can reduce street light energy use by as much as 70 percent. Besides saving energy and reducing electricity costs, LED lights also have a longer useful life requiring less maintenance. The installation of efficient street lights is a demonstration of the City's commitment to resource conservation that can be seen by the community it serves. This measure is not included in the Sustainable Jersey priority climate actions for Gold Star certification.

Currently, the City is responsible for the electricity consumption of more than 2,000 street lights installed within the City jurisdiction. Of these, 1,871 could be upgraded to LED technology. The lights are owned by the utility (PSE&G) and the City pays monthly fees for each light, poles, etc. plus the charges for electricity consumption. The fees per light vary depending on the type (metal halide, high pressure sodium, mercury vapor, etc.) and the wattage of each fixture. The average electricity consumption is ~190,000 kWh per month, costing approximately $60,000 per

month on average. Since the City does not own the lights, there are two possible pathways to LED street light conversion: upgrade to utility-owned LEDs according to an agreed upon tariff, or the City purchases their own LED streets lights and replacing the utility-owned ones. The discussion of the two alternatives would require an in-depth analysis of the utility tariffs and fees vs. the cost of purchasing, installing, and maintaining the street lights on its own. Both solutions have pros and cons; in general, the option of purchasing the lights should deliver higher long-term savings at the cost of a higher upfront investment. Sizing of the lights can also be tailored to City's specification rather than going by the standard options offered by the utility. The City should also explore taking advantage of NJBOP programs facilitating the transition to LED lighting, similarly to what they did for the Direct Install program for buildings and facilities.

ClearPath includes a tool to estimate the energy and emissions reduction benefits achievable by the LED retrofit project. An inventory of the current street lights installed in the City jurisdiction shows many different types and sizes of lights including high pressure sodium (HPS); metal halide (MHL); and mercury vapor (MRC).

Light Type	Light Count	% of Total	Average Watts per Type	Average LED Replacement Wattage	Average Cost of Retrofit ($/light)	Total Cost
HPS	1157	61.84%	273.90	120	$309	$357,513
MHL	611	32.66%	145.62	120	$309	$188,799
MRC	103	5.51%	382.52	120	$309	$31,827
					Total	$578,139

ClearPath provides a suggested LED replacement for various light types and average wattage size currently installed and a common replacement size was selected for all the different lights. In reality, depending on the street location, smaller LED could be installed, further reducing energy consumption. ClearPath estimated the cost of the replacement at $309 for each LED light, which is in line with current estimates found in literature. As such, the estimated cost of purchasing and replacing all the lights would be $578,139. The annual energy savings are estimated as ~1,128,000 kWh/year, which is ~46 percent of the current total consumption for street lights (including already converted LED and unmetered lights). The annual savings are estimated ~$86,900/year in electricity cost only, not counting additional savings due to lower demand charges and potentially reduction in annual fees for equipment supply and maintenance. The GHG emission reduction is estimated at approximately 388 tCO_2e per year.

Change Electricity Use (kWh/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost	Electricity Savings ($/Year)
-1,128,300	-388	$578,100	-$86,900

**Assuming municipal ownership of replacement LED street lights.*

6.6 Traffic Lights Conversion to LED

Similar to the previous measure, this measure consists of upgrading the traffic signal lights in operation within the City boundary to advanced technology such as LED. The conversion to LED will significantly reduce traffic lights energy use, saving energy, and maintenance cost due to the longer lifespan of LED bulbs.

Currently there are 23 intersections regulated by City operated traffic lights; additional intersections are controlled by traffic lights operated by Hudson County. We assumed 4 fixtures

per intersection, each with 3 lights, for a total of 276 bulbs. Typical incandescent traffic lights use 150-watt bulbs that are operating 24 hours a day. For the ClearPath model, we assumed LED arrays consuming 20 watts instead, significantly reducing overall energy consumption. The cost of LED conversion was assumed the same as for street lights, at $309 for each fixture of 3 lights. Based on this assumptions, the overall energy saving was estimated as 104,700 kWh/year or 86 percent reduction compared to the baseline. The annual cost saving was estimated as $8,100/year, accounting only for the saving in electricity delivered cost, compared to an estimated implementation cost of $28,400. The overall annual GHG emissions reduction was estimated as 36 tCO_2e/year.

Number of City Operated Intersections	Estimated Traffic Light Fixtures	Change Electricity Use (kWh/Year)	Emission Reduction (tCO_2e/year)	Estimated Cost	Electricity Savings ($/Year)
23	92	-104,700	-36	$28,400	-$8,100

6.7 Electric-Hybrid Vehicle Replacement

The vehicle fleets operated by the various departments are responsible for a large share of the City's GHG emission. According to the vehicle inventory provided by the City, passenger cars and small quad vehicles represent a large share (72 percent) of the City gasoline vehicle fleet (Environmental Services, Community Development, Administration, Human Services, Buildings, Transportation and Parking). A similar share is present in the Hoboken parking Unit fleet, which is 88 percent composed of passenger cars and quad/tricycle vehicles. These vehicles are the ideal candidates for replacement with hybrid or electric vehicles due to their frequent use in traffic with light loads. Light and heavy-duty hybrid trucks may not be commercially available yet, though a few models are appearing on the market. Same for police vehicles, which is a very limited niche market with few vehicles available and very limited options for hybrid engines. Nonetheless, for the scope of simulating a replacement of gasoline engine vehicles with hybrid or electric vehicles, we assumed the replacement of the passenger/quad vehicles in the City fleet with hybrid vehicles, while we assumed that similar vehicles in the HPU fleet would be replaced with electric or plug-in hybrid vehicles. This combination of measures is consistent with Renewable Jersey priority climate actions for Gold Star certification. The electric/plug-in hybrids provide an even better fuel efficiency and we assumed 99 mpg for the electric/plug-in hybrid vehicles, instead of the 35 mpg mileage assumption for hybrid vehicles (both for city driving). The baseline average mileage for the existing fleet of gasoline passenger cars/quad/tricycles was assumed at 18 mpg, with an estimated VMT of 195,042 miles/year for the City's 26 vehicles and 236,900 miles/year for the HPU 29 vehicles. All these values were estimated from the City fleets inventory data and fuel consumption records.

According to ClearPath estimates, replacing one passenger vehicle with a hybrid engine model would more than double the fuel efficiency and save approximately 1.5 tCO_2e per year at current level of miles driven. For a full electric vehicle or a plug-in hybrid where fuel use would be drastically reduced or eliminated, the reduction amounts to 3.2 tCO_2e/year. The overall fuel cost savings for each fleet amount to $13,500 for the City fleet and $32,000/year for the HPU fleet.

Gasoline Fuel Fleet	Vehicles Replaced	Estimated Cost	Change Fuel Use (Gal/Fleet/Year)	Fuel Savings ($/Fleet/Year)*	Emission Reduction (tCO_2e/year)
City Fleet – Passenger Vehicles	26	$35,000/vehicle	-4,555	-$13,700	-40
HPU Fleet – Passenger Vehicles	29	$35,000/vehicle	-10,706	-$32,100	-94

**Assuming $3.00/gal fuel cost for gasoline.*

6.8 Low Emissions Vehicles in the City Public Transit Fleet

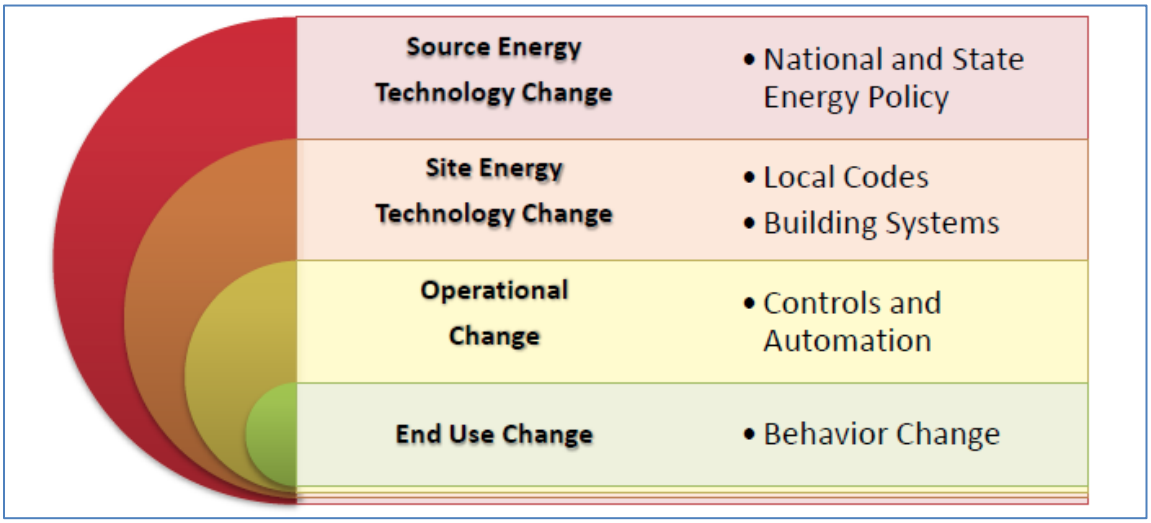
The City operates a small fleet of five paratransit buses, named HOP buses, providing a network of public transit transportation within Hoboken. Additional bus routes are operated by New Jersey Transit, but these are outside of the City's control and operation. The vehicles are gasoline engine small buses and for 2017 the records provided by the City show a fuel consumption of 20,672 gallons of fuel and estimated 206,719 miles for VMT. The measure consists of replacing or retrofitting the current gasoline vehicles with equivalent ones running on Compressed Natural Gas (CNG) fuel. The CNG fuel emits lower volume of CO_2e per mile and could also be fueled with renewable fuel, further reducing the GHG emissions, if the City were to purchase bio-CNG produced for example by recovering biogas emitted from a landfill or a wastewater plant sludge bio-digester. The fuel conversion measure would also require the installation of a CNG fueling station fed from a utility gas supply line, adding to the overall cost. On the other hand, once the CNG fueling infrastructure is installed, it could also be used to expand the CNG fueling to other City vehicles such as sanitation trucks, a common conversion for municipalities operating landfills and generating their own bio-CNG. On average it was estimated that each truck replacement could cost $80,000. The fuel cost savings amount to approximately $20,000/year for the entire HOP fleet, according to the average market price difference of $1 per gallon of gasoline equivalent fuel. The GHG emission reduction achievable would be approximately 67 tCO_2e/year, or one third of the total HOP fleet baseline emissions (~182 tCO_2e/year).

HOP Fleet Vehicles	Emission Reduction (tCO_2e/year)	Estimated Cost	Fuel Savings ($/Year)*
5	-67	$80,000/vehicle	$20,240

7. Emission Reduction Planning

The ClearPath GHG inventory tool includes a planning module that allows evaluating the outcomes in terms of energy and emissions reductions of the GHG emission measures identified in the previous chapter. The planning module provides a tool for assessing the effectiveness of the proposed climate actions in achieving the planned reduction goals against the baseline year emissions. The module includes the option of selecting the implementation timeline for each measure, allowing testing different strategies to design the optimal sequence of implementation. This is very important for those measures that require considerable financial investment or lengthy planning and preparation before they can be launched. This would be the case for example of the street lights LED conversion or the solar PV installation previously described. The objective is to plan the climate actions in order to meet the GHG reduction goals timeline, balancing the priority of achieving the emission as early as possible with financial budget and costs constraints. Where possible, measures should be planned prioritizing those measures that have an impact to the source of emissions, followed by those that are focused on end use and behavioral changes, which may be harder to fully implement or follow. On the other hand, measures targeting the sources may be more complex and expensive (for example upgrading a power plant) requiring more time to prepare and implement, than a relatively simple building management policy setting rules on thermostats settings to reduce waste of heating energy. The following diagram from ICLEI's ClearPath Planning Module User Manual provides a useful guidance on the hierarchy of reduction measures.

Figure 12: Hierarchy of Emissions Reduction Measures



Source: ICLEI ClearPath Planning Module User Guide, February 2014.

The following table lists the proposed reduction measures in order of priority, based on reduction potential, cost and complexity of implementation.

Table 18: Summary of GHG Emissions Reduction Measures - Pros & Cons

Reduction Measure	Expected GHG Emission Reduction (tCO_2e/year)	Priority	Comment
Renewable Power Purchase Agreement	-156 to -2,407	1	Simple implementation; Low-High Cost; Potentially significant GHG emissions reduction
Implement Energy Efficiency Upgrades at City Hall	-28	1	Medium complexity implementation; Medium Cost; Medium GHG emissions reduction
Energy Efficiency Upgrades at other City facilities.	-242	1	Medium complexity implementation; Medium Cost; Medium GHG emissions reduction
Install LED street lights	-388	2	Complex implementation; High Cost; Medium GHG emissions reduction
Install photovoltaic solar energy systems on City buildings	-224	2	Complex implementation; High Cost; Medium GHG emissions reduction
Install LED traffic lights	-36	2	Medium complexity implementation; Medium Cost; Low GHG emissions reduction
Phase in hybrid electric and electric vehicles into the City's vehicle fleet.	-55	3	Low complexity implementation; Medium to High Cost; Low GHG emissions reduction
Phase in low-emission buses into the City's Public Transit fleet.	-67	3	Medium complexity implementation; High Cost; Medium GHG emissions reduction

The priority order should also take into account the reduction goals at year 1, 3 and 9, planning the implementation of the measures in order to meet the reduction timeline while avoiding concentrating investment cost in a short time span. The data for each measure were input in ClearPath planning module and several tests were performed. The table below shows a proposed implementation plan, allowing sufficient time for the City to plan for the financing and implementation of the different measures. According to this plan, the Net-Zero goal is reached by 2025 when the Scope 2 emissions are reduced to zero due to energy savings measures combined with renewable electricity generation and power purchase agreements.

Table 19: GHG Emission Reduction Measures Implementation Timeline - Net-Zero 2025 Scenario

Reduction Measure	Implementation Start Year	Implementation End Year	Forecast End Year
Municipal Power Purchase Agreement - 6.5% Baseline	2019	2020	2029
City Hall Building retrofit - Direct Install	2019	2029	2029
Multi-Building retrofit - Direct Install	2019	2029	2029

Reduction Measure	Implementation Start Year	Implementation End Year	Forecast End Year
Municipal Power Purchase Agreement - 19.5% Consumption	2021	2024	2029
LED Traffic Lights Retrofit	2021	2029	2029
LED Streetlights Retrofit	2022	2029	2029
City Car Fleet - Hybrid Vehicles	2023	2029	2029
Rooftop Solar PV Installation	2023	2029	2029
HPU Car Fleet - Hybrid/Electric Vehicles	2024	2029	2029
HOP Fleet Fuel Switch - CNG	2024	2029	2029
Municipal Power Purchase Agreement - 100% Consumption	2025	2029	2029

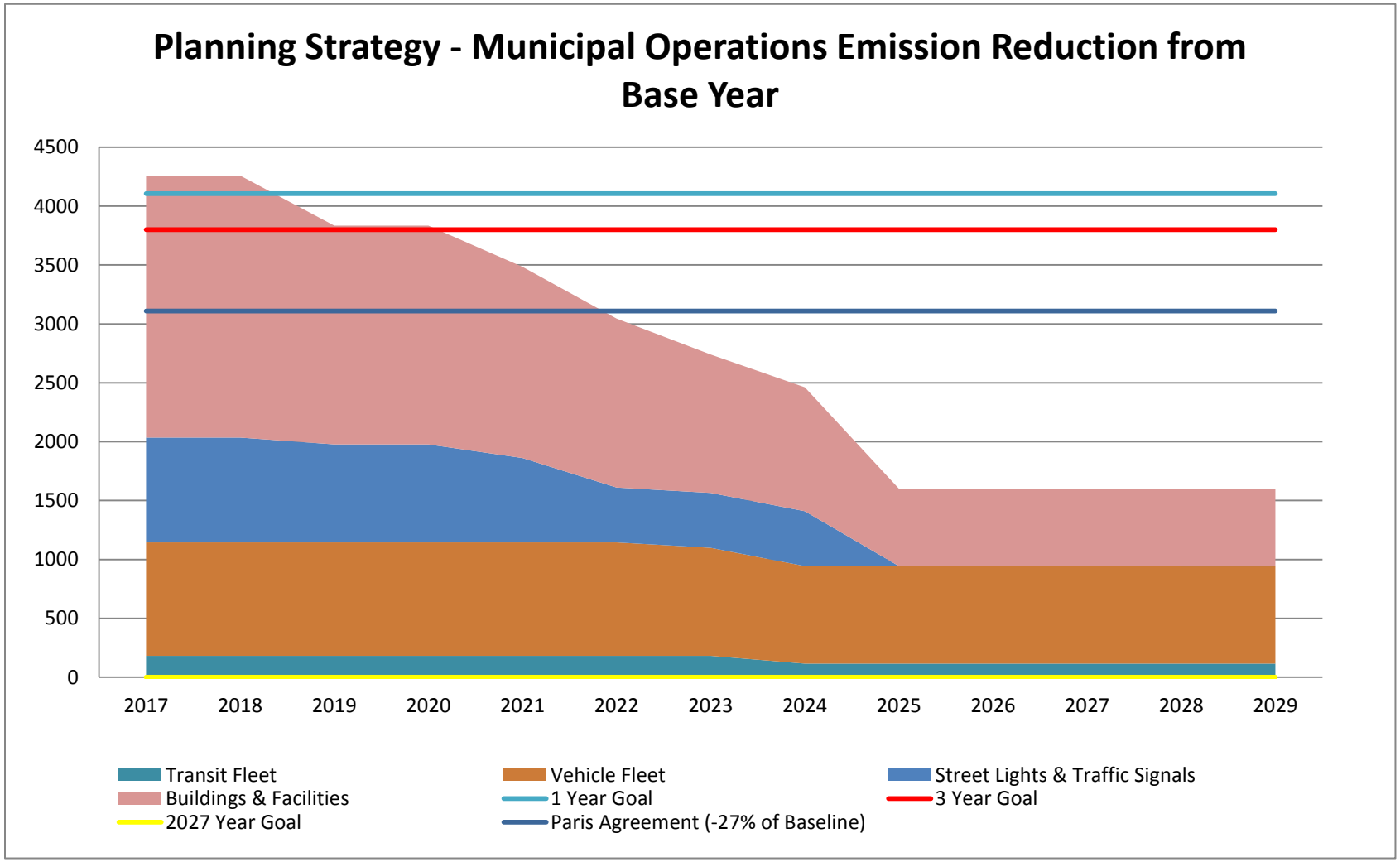
The results of the reduction measures planning and the estimate of the emission reduction are shown in the following tables and diagrams.

Table 20: GHG Emission Reduction Plan – Net-Zero 2025 Scenario (tCO_2e)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Transit Fleet	182	182	182	182	182	182	182	116	116	116	116	116	116
Vehicle Fleet	963	963	963	963	963	963	917	828	828	828	828	828	828
Street Lights & Traffic Signals	890	890	832.15	832.15	716.45	466	466	466	0	0	0	0	0
Buildings & Facilities	2224	2224	1857	1857	1623	1434	1175	1052	657	657	657	657	657
Total Emissions	**4,259**	**4,259**	**3,834**	**3,834**	**3,484**	**3,045**	**2,740**	**2,462**	**1,601**	**1,601**	**1,601**	**1,601**	**1,601**
Reduction to 2017 Baseline	**0**	**0.0%**	**-10.0%**	**-10.0%**	**-18.2%**	**-28.5%**	**-35.7%**	**-42.2%**	**-62.4%**	**-62.4%**	**-62.4%**	**-62.4%**	**-62.4%**
1 Year Goal	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106
3 Year Goal	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799
Paris Agreement (-16% of Baseline)	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578

The emissions reductions are calculated according to the 2017 baseline. The results in the table show that the reduction measures are expected to achieve the planned reduction goals, possibly exceeding the three-year goal (10.8 percent) and the Paris agreement (-16 percent by 2027). The Scope 2 emissions are minimized by 2025, the year when the 100 percent PPA agreement on the residual electricity consumption becomes active.

Figure 13: GHG Emission Reduction Plan – Net Zero 2025 Scenario



The table below shows an alternative implementation plan, reducing the time for the City to plan for the financing and implementation of the different measures. According to this plan, the Net-Zero goal is reached by 2022 when the Scope 2 emissions are reduced to zero due to energy savings measures combined with a more aggressive renewable electricity power purchase agreements and generation.

Table 21: GHG Emission Reduction Measures Implementation Timeline – Net-Zero 2022 Scenario

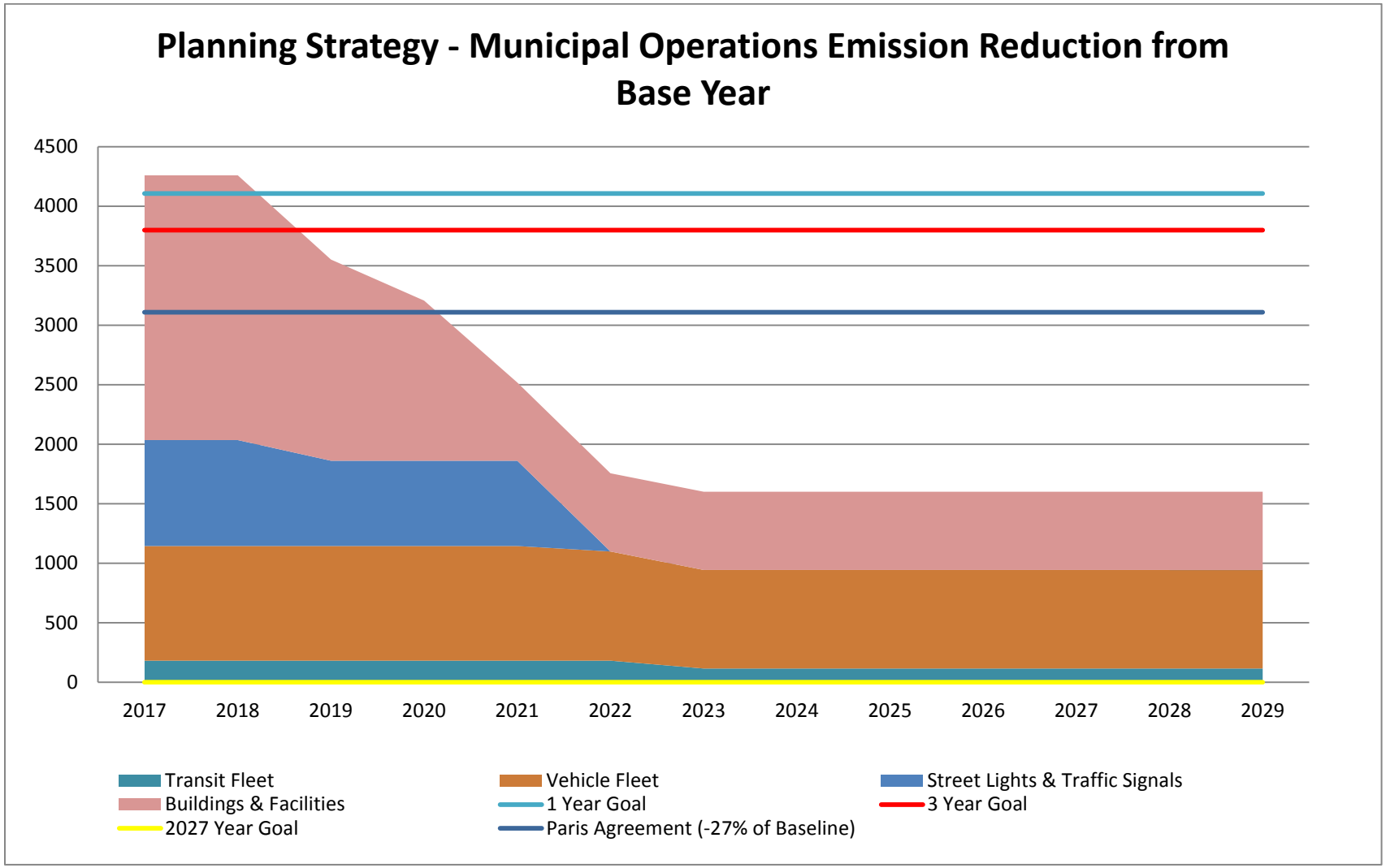
Reduction Measure	Implementation Start Year	Implementation End Year	Forecast End Year
Municipal Power Purchase Agreement - 19.5% Baseline	2019	2020	2029
City Hall Building retrofit - Direct Install	2019	2029	2029
Multi-Building retrofit - Direct Install	2019	2029	2029
LED Traffic Lights Retrofit	2020	2029	2029
LED Streetlights Retrofit	2020	2029	2029
Rooftop Solar PV Installation	2020	2021	2029
Municipal Power Purchase Agreement - 100% Consumption	2022	2029	2029
City Car Fleet - Hybrid Vehicles	2022	2029	2029
HPU Car Fleet - Hybrid/Electric Vehicles	2023	2029	2029
HOP Fleet Fuel Switch - CNG	2023	2029	2029

Table 22: GHG Emission Reduction Plan – Net Zero 2022 Scenario

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Transit Fleet	182	182	182	182	182	182	116	116	116	116	116	116	116
Vehicle Fleet	963	963	963	963	963	917	828	828	828	828	828	828	828
Street Lights & Traffic Signals	890	890	716.45	716.45	716.45	0	0	0	0	0	0	0	0
Buildings & Facilities	2224	2224	1690	1345	657	657	657	657	657	657	657	657	657
Total Emissions	4,259	4,259	3,551	3,206	2,518	1,756	1,601	1,601	1,601	1,601	1,601	1,601	1,601
Reduction to 2017 Baseline	0	0.0%	-16.6%	-24.7%	-40.9%	-58.8%	-62.4%	-62.4%	-62.4%	-62.4%	-62.4%	-62.4%	-62.4%
1 Year Goal	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106	4,106
3 Year Goal	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799	3,799
Paris Agreement (-16% of Baseline)	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578	3,578

The emissions reductions are calculated according to the 2017 baseline. The results in the table show that the reduction measures are implemented according to a more aggressive schedule. The reduction goals achieved sooner than in the previous scenario, exceeding the three-year goal (10.8 percent) in the year 1 (2019) and the Paris agreement (-16 percent by 2025) already in year 2020. The Scope 2 emissions are minimized by 2022, the year when the 100 percent PPA agreement on the residual electricity consumption becomes active.

Figure 14: GHG Emission Reduction Plan – Net-Zero 2022 Scenario



9. Uncertainty Assessment and Quality Assurance

With regard to a GHG Inventory, quality refers to the general accuracy and consistency between an organization's actual emissions and quantified emissions. The difference between actual and quantified emissions results from uncertainty and error introduced by activities such as data collection, data management, calculations, and reporting. Inventory quality is impacted as data progresses from individual sources to the final report.

The inventory contains reporting uncertainty resulting from the potential for errors to be introduced in certain activities. Overall uncertainties are as follows:

- Not all data was received from primary sources (i.e., invoices) and backup data was not provided for the information recorded. Thus, errors present in the initial data will be transferred to errors in the emission calculations.
- Default emission factors, though used as a best practice, may present a level of uncertainty from the actual emissions.

10. Verification of this Report

This report, the information it contains, and the data it is based upon have not been verified by an external third party.

Appendix 1

Detailed schedule of properties – City of Hoboken

ID	Location	Type	Sq. Ft.	Floors	Year Built
22918	94 Washington St	Municipal Building	22500	4	1900
22919	250-254 Fifth St	Library	6575	4	1900
22920	55 Madison St	Madison Fire House	2380	3	1960
22921	1313 Washington St	Uptown Fire House	3300	3	1960
22922	801 Clinton St	Fire House	2700	3	1970
22923	201-205 Jefferson St	Fire Headquarters	10625	3	1970
22924	111 Jefferson St	Recreation Department	2500	1	1970
22925	213 Bloomfield St	Exempt Hall, Fire House Museum	1500	2	1970
22926	401 Hudson St	Stevens Park, Little League Building	400	2	1980
22927	400-422 Garden St	Church Square Park - Gazebo	100	1	1990
22928	10th & 11 St on Hudson	Elysian Park - Storage Hut	125	1	1980
22929	120-134 Grand St	Multi Skill Community Center	40000	2	1970
22930	120-134 Grand St	Skating Rink	0	0	1900
22931	116-118 Jackson St	Jackson Street Park	5000	1	1970
22932	106-124 Hudson St	Police Station	23242	2	1960
22933	Sinatra Park at 4th & Sinatra Drive	Frank Sinatra Field House	1600	1	1980
22934	56-66 Park Ave a/k/a 256 Observer Highway	Service Garage	24712	2	1970
22935	1301 Hudson St	Hoboken Museum - Contents Only	2000	1	1960
22936	112-134 River St	Garage B	226434	6	1980
22937	210-222 River St	Garage D	128275	6	1980
22938	310-322 River St	Garage G	128275	6	1980
22939	916 Garden St	916 Automated Parking Facility	10246	5	1980

ID	Location	Type	Sq. Ft.	Floors	Year Built
22940	259-265 11th St	Open Lot #1 Park & Lock - Liability Only	7200	0	1970
22941	200 Willow Avenue	Open Lot #2 Park & Lock - Liability Only	7200	0	1970
22942	304-330 Clinton St	Midtown Garage	21862	5	1970
22943	Castle Point Park, 7th St at Sinatra Drive	Gazebo	200	1	1970
22944	Maxwell Place Boathouse, 11th St at Sinatra Drive	Boathouse	1000	1	1970
22945	Hoboken Cove Park 15th St & Park Avenue	Playground (equipment) & Walkway	84868	1	2009
22946	Pier A Park, 1st St at Sinatra Drive	Gazebo, Amphitheater, Bike Trail & Tree Grove	278901	1	1980
22947	1015-1129 Sinatra Drive North	Liab Only - Maxwell Place Park (License Arrangement w/ outside entity)	5000	0	
22948	1221 Willow Avenue	Legion Park - Liability Only	5063	0	1970
22949	300-304 Madison Street	Madison Street Park - Liab Only	7500	0	1980
22950	1601 Willow Ave	1600 Park	15352	0	1900
22951	16th Street Pier	Pier - Liab Only	20000	0	1900
22952	East of Park Avenue	Pier - Liability Only	27930	0	1900
22953	North of 14th Street	Pier - Liability Only	300000	0	1900
22954	315 Sinatra Drive	Pier 1	252747	0	2011
22955	458 2nd St	Parking for Fire HQ	5000	0	1960
22956	229-233 Jackson St	Land - Liability Only	7500	0	1970
22957	85-91 Sinatra Drive	Walkway - Liability Only	8470	0	1960
22958	201 Sinatra Drive	Esplanade/Walkway - Liability Only	51420	0	1970
22959	Foot of Newark St	Walkway off Lot 3 - Liability Only	1250	0	1960

ID	Location	Type	Sq. Ft.	Floors	Year Built
22960	1601-1623 Willow Avenue	Land - Liability Only	48024	0	1960
22961	1015-1129 Sinatra Drive North	Land - Liability Only	10000	0	1970
22962	1011-1125 Sinatra Drive North	Row Streets - Liability Only	2500	0	1970
22963	514-526 Madison St	Land Lease - Liability Only	17500	0	1980
22964	Park Avenue	LIABILITY ONLY	20000	0	2000
22965	109 Jefferson Park	Playground Boys & Girls Club	2500	0	1970
22966	1501 Park Avenue	Harborside Park	0	0	
22967	River Road	Waterfront	0	0	
22968	58 Jackson St	Southwest Park	0	0	
24571	256 5th St	Public Library	2735	2	