# Greenhouse Gas Emissions Inventory
# Community Activities
# 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
NJRTM-E - North Jersey Regional Transportation Model- Enhanced
NJTPA - North Hudson Traffic Planning Authority
$N_2O$ – Nitrous Oxide
PSE&G - Public Service Electric and Gas Company
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
US EIA - United States Energy Information Administration
WRI – World Research Institute

# 1. 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 (also referred to as the City within this report) and the municipal operations activities in 2017. The community GHG inventory was conducted 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 instead conducted 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 greenhouse gas 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 community GHG inventory emissions; a separate report was prepared for the municipal operations GHG emissions.

### *Community Inventory*

The scope of the inventory includes all emissions sources reportable under the GPC's city-induced framework. This reporting approach includes the GHG emissions attributable to activities taking place within the geographic boundary of the city, aggregated as Scope 1, Scope 2, and selected Scope 3 emissions.

The city-induced framework provides two reporting level options: BASIC or BASIC+. The BASIC level includes Scope 1 and Scope 2 emissions from stationary energy and transportation, as well as Scope 1 and Scope 3 emissions from waste generated by the community. The BASIC+ level includes additional Scope 3 categories such as upstream and downstream processes and products use. The Community of Hoboken opted to follow the BASIC reporting level.

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 ($tCO_2e$), the global standard unit used to measure GHG emissions.

**Table 1: Summary of GHG Inventory**

| | |
|---|---|
| Reporting Protocol | World Resources Institute/Local Governments for Sustainability (ICLEI)'s Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, v1, 2014 |
| Reporting Tool | ICLEI ClearPath – Community Track - https://clearpath.icleiusa.org |
| Geographic Boundary | City of Hoboken Municipal Boundary |
| Reporting Framework | City-Induced Framework - BASIC Reporting |
| Operational Boundary | Scope 1, Scope 2, selected Scope 3 from waste generated |
| Inventory Reporting Period | January 1 to December 31, 2017 |
| Base Year | 2017 |
| Greenhouse Gas | Kyoto Seven GHG |
| GWP Defaults | IPCC 5$^{th}$ Assessment Report (AR5) |

## *Community GHG Emissions by Scope*

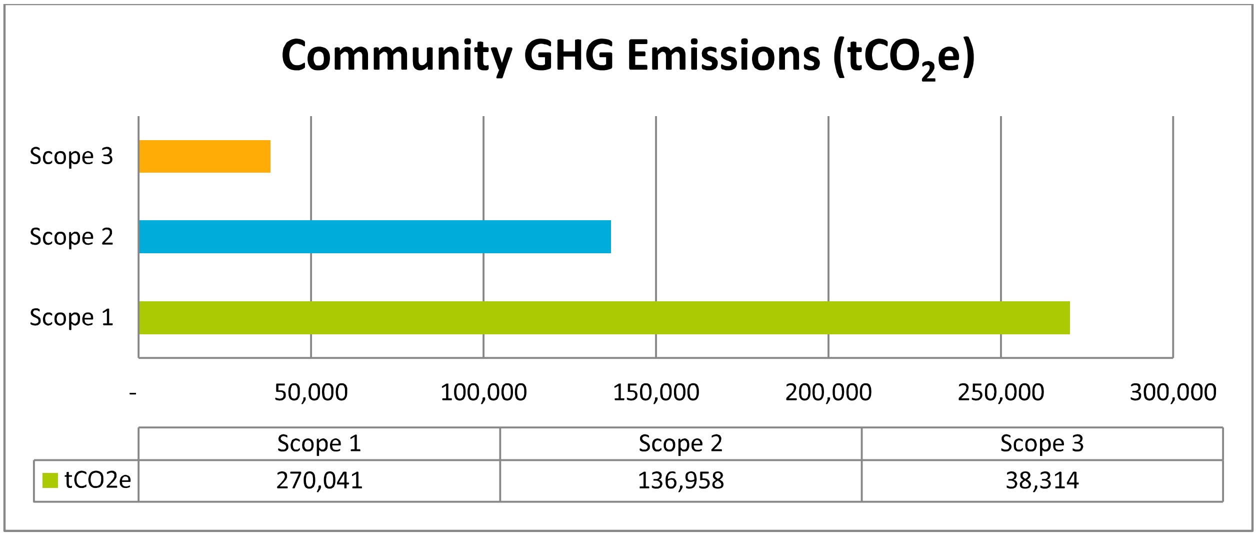
The Community's total Scope 1 GHG emissions for 2017 amounted to 270,041 $tCO_2e$. These total emissions originate from stationary combustion such as natural gas for heating, and from mobile combustion such as gasoline and diesel consumption by the Community vehicles.

The City's total Scope 2 GHG emissions for 2017 amounted to 136,958 $tCO_2e$. In addition, the Scope 3 emissions, selected according to the BASIC reporting level, amounted to 38,314 $tCO_2e$.

**Table 2: Total GHG Emissions by Scope ($tCO_2e$)**

| GHG Emissions | $tCO_2e$ |
|---|---|
| Scope 1 | 270,041 |
| Scope 2 | 136,958 |
| Scope 3 | 38,314 |
| Total | 445,313 |

**Figure 1: Total GHG Emissions by Scope ($tCO_2e$)**




The distribution of Scope 1, Scope 2, and Scope 3 emissions by sector is shown in percentage and in $tCO_2e$ in the charts below.

**Figure 2: Total GHG Emissions by Sector in Percentage**

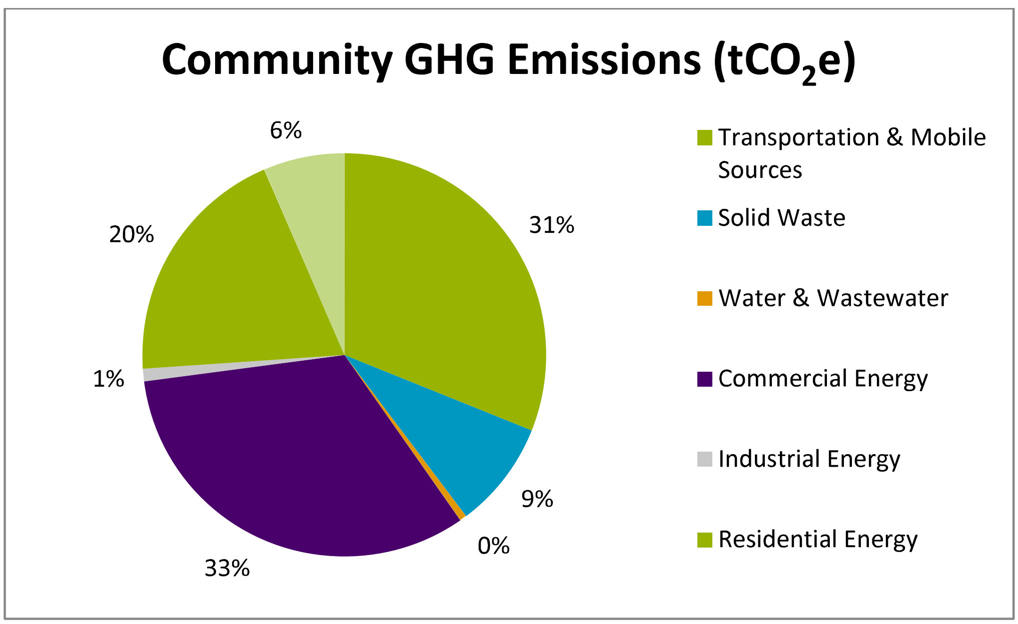
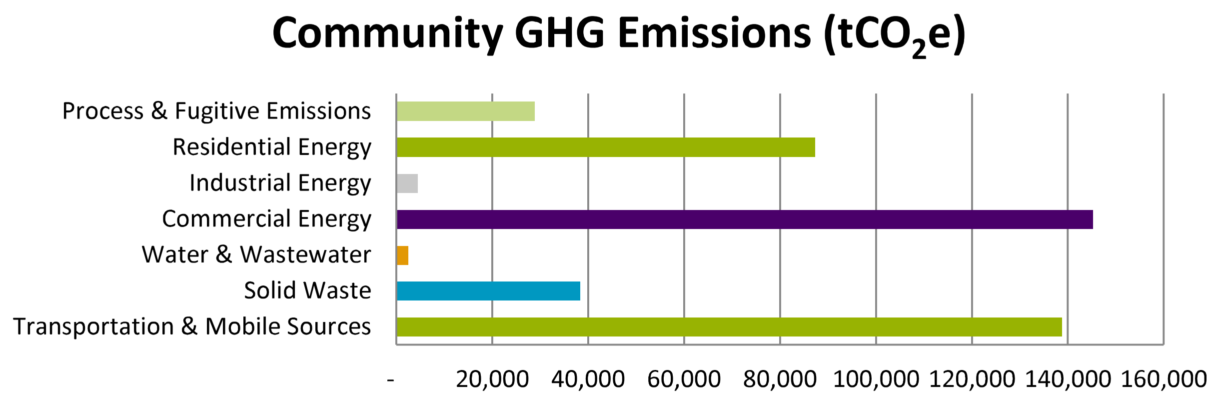


**Figure 3: Total GHG Emissions by Sector ($tCO_2e$)**




| | Transportation & Mobile Sources | Solid Waste | Water & Wastewater | Commercial Energy | Industrial Energy | Residential Energy | Process & Fugitive Emissions |
|---|---|---|---|---|---|---|---|
| GHG Emissions (tCO2e) | 138,768 | 38,314 | 2,457 | 145,239 | 4,441 | 87,260 | 28,833 |

The results highlight the predominance of the emission from buildings and facilities (residential and commercial energy) as the major sources of GHG emissions. Scope 1 emissions from mobile fuel combustion rank as the next largest source.

# 2. 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 added 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 City of Hoboken Community GHG inventory includes the emissions generated or induced by the City residents and businesses, including those produced by power generation, waste disposal, or wastewater treatment facilities, if present within the City geographic boundaries. In accordance with the GPC city-induced framework the GHG inventory also includes the emissions from transportation by vehicles operating within the City boundaries, according to certain criteria better explained in the following sections, notwithstanding if the vehicles are operated by City residents or travelers to and from the City boundary.

Because the data required for the inventory was collected with a top-down approach (for example, aggregated energy data provided by the local utility), the Community inventory also includes the emissions by the municipal government operations. As previously mentioned, the emissions from the municipal operations sources were also accounted for according to a separate specific protocol in a separate GHG Inventory conducted in parallel with the Community Inventory.

# 3. 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[2]. The number of households according to the same 2017 census estimates is 24,812 and the population density according to the 2010 census data is 39,220 people per square mile.

The City territory borders the municipalities of Jersey City to the west and south; and 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.

**Table 3: City Demographic Data**

| Demographic | Data |
|---|---|
| Population (2017) | 55,131 |
| Households | 24,812 |
| Civilian Labor Force, percent of population 16+ | 78.9 |
| Median Household income (2013-2017) | $127,523 |
| Gross Domestic Product (2016 - $million)[3] | $4,313 |
| Businesses, all firms (2012) | 5,946 |
| Hoboken residents working elsewhere (2015)[4] | 30,179 |
| Hoboken residents working in Hoboken (2015)[4] | 2,267 |
| Non-Hoboken residents working in Hoboken (2015)[4] | 16,109 |

Source: US Census QuickFacts, unless noted.

The City's recently updated Master Plan includes a description of the existing land uses and associated acreage, summarized in the following table and map.

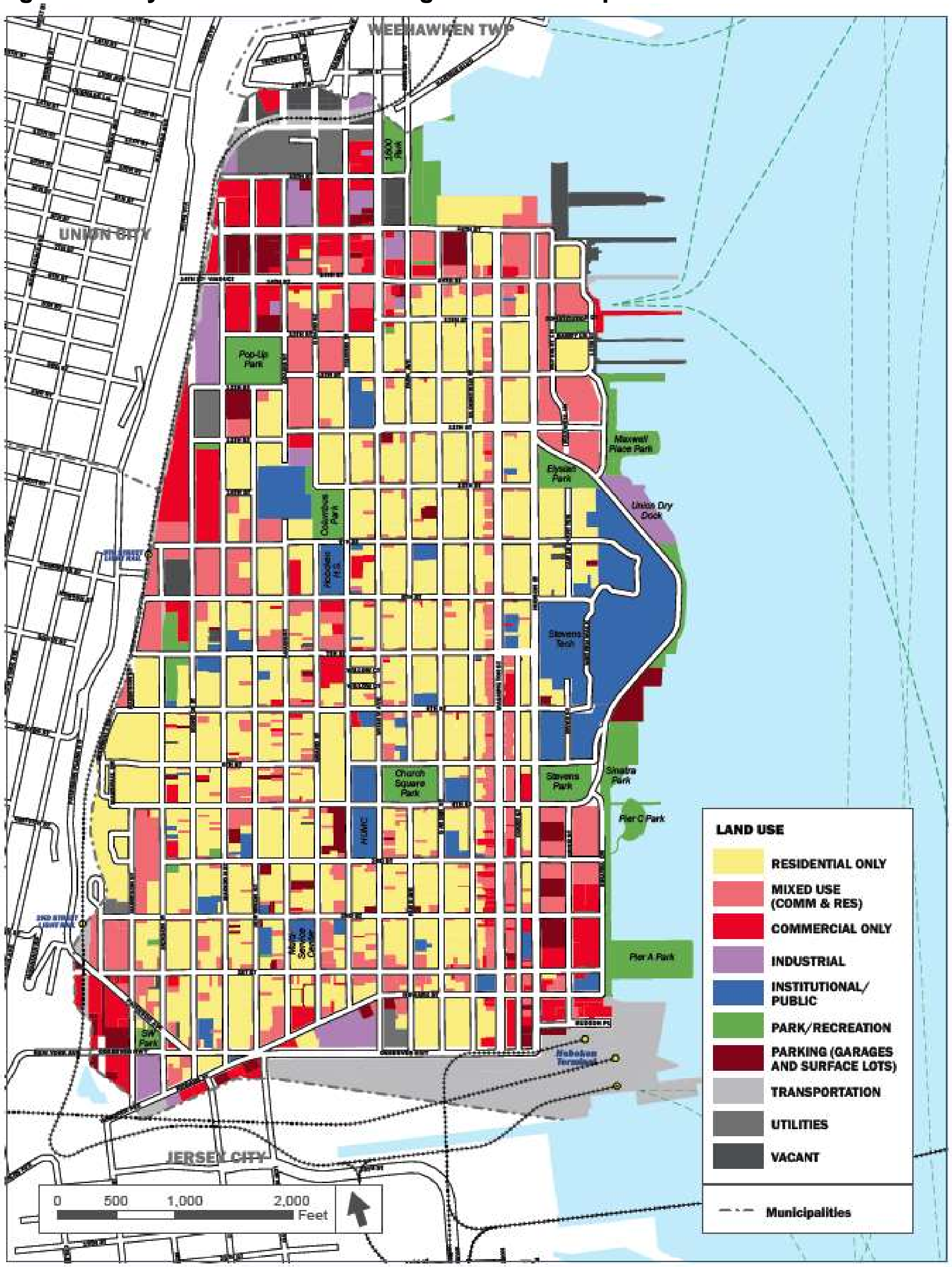
[1] https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml
[2] https://www.census.gov/quickfacts/hobokencitynewjersey
[3] https://www.bea.gov/news/2017/gross-domestic-product-metropolitan-area-2016
[4] US Census, On the Map – Work Area Profile Analysis – provided by City of Hoboken.

**Table 4: Existing Land Use and Acreage[5]**

| Land Use by Parcel | Acres | Percent |
|---|---|---|
| Residential Only | 217 | 39 |
| Mixed Use (Comm. & Res.) | 84 | 15 |
| Commercial Only | 54 | 10 |
| Industrial | 17 | 3 |
| Institutional/Public | 57 | 10 |
| Parks/Recreation | 42 | 8 |
| Parking (Surface & Garage) | 20 | 4 |
| Transportation (Excluding Streets) | 45 | 8 |
| Vacant | 12 | 2 |
| Total | 548 | 100 |

[5] City of Hoboken Master Plan - Land Use Element 2018 – Table 1

**Figure 4: City of Hoboken - Existing Land Use Map**[6]




There are no solid waste disposal facilities within the Hoboken geographic boundary, but the North Hudson Sewerage Authority (NHSA) operates a wastewater treatment facility located on Adams Street on the northern end of the Hoboken territory. This facility serves the communities of Hoboken, Union, and Weehawken, collecting sewer and wastewater for treatment and disposal.

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[6] City of Hoboken Master Plan - Land Use Element 2018 – Figure 2

The City operates a fleet of five paratransit buses providing public transit within the City territory. In addition, the Community is served by several public transit modes provided by New Jersey Transit (bus, light rail, commuter rail) as well as ferry services connecting the City to New York City and other communities on the Hudson River.

## 3.1 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.

## 3.2 GHG Inventory Reporting Protocol

The City of Hoboken Government Operations GHG inventory was conducted in accordance with Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), developed by the World Resources Institute (WRI) in partnership with the Local Governments for Sustainability (ICLEI). The GPC is based on WRI's "Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard," which provides the standards and guidance for companies and other types of organizations preparing a GHG emissions inventory. The goal of the GPC is to offer additional guidance to cities on applying the GHG Protocol within the context of local community. The GPC provides a standardized method and procedures to assist local governments in quantifying and reporting GHG emissions associated with the activities of the community they govern.

## 3.3 GHG Inventory Reporting Tool

The GHG inventory was prepared using ICLEI's ClearPath Tool, an online platform designed to incorporate all the GPC requirements for inventory data including all parameters, factors, and methodologies necessary to perform the GHG emissions quantification. 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.

## 3.4 GHG Inventory Boundaries

The inventory boundaries identify the geographic area, time span, gases, and emission sources covered by a GHG inventory. The following paragraphs identify the boundaries selected for the City of Hoboken Community GHG Inventory.

### *3.4.1 Geographic Boundary*

The geographic scope of the emissions inventory determines which emissions are accounted for and reported by the Hoboken community. The geographic boundary applied for the Hoboken community inventory is the City of Hoboken jurisdiction boundary, as identified in the City's official maps (see Figure 4 for Land Use Map).

### *3.4.2 GHG Inventory Reporting Period – Base Year*

This GHG inventory report covers GHG emissions from the city-wide activities within the boundaries described 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-wide activities. The baseline will be used to establish emissions reductions targets and track progress towards achieving them.

### *3.4.3 Greenhouse Gases and GWP*

The Inventory accounts for the emissions of the seven gases currently required for national GHG inventory reporting under the Kyoto Protocol. The following table lists the gas included and their 100-year time horizon GWP according to the IPCC Fifth Assessment Report, 2014 (AR5).

**Table 5: Greenhouse Gas and GWP (AR5 100-year time horizon)**

| Greenhouse Gas | Chemical Formula | Global Warming Potential (AR5 100-year) |
|---|---|---|
| Carbon Dioxide | $CO_2$ | 1 |
| Methane | $CH_4$ | 28 |
| Nitrous Oxide | $N_2O$ | 265 |
| Hydrofluorocarbons | HFCs | Various |
| Perfluorocarbons | PFCs | Various |
| Sulfur Hexafluoride | $SF_6$ | 23,500 |
| Nitrogen Trifluoride | $NF_3$ | 16,100 |

### *3.4.4 GHG Emissions Sources - Sectors*

Community inventories differ from corporate or local government entities inventories because the organizational boundaries definitions (operational control vs. financial control) do not apply. Instead the GPC identifies the sectors that should be applied to classify the GHG emission from cities.

- stationary energy;
- transportation;
- waste;
- industrial processes and product use (IPPU);
- agriculture, forestry, and other land use (AFOLU);
- any other emissions occurring outside the geographic boundary as a result of city activities (collectively referred to as Other Scope 3).

Each one of these sectors includes sub-sectors to better identify the emission sources. The following table summarizes the sectors and sub-sectors according to Table 3 of the GPC.

**Table 6: GPC Emission Sources - Sectors and Sub-sectors**

| Sector | Sub-Sectors |
|---|---|
| Stationary Energy | Residential buildings |
| | Commercial and institutional buildings and facilities |
| | Manufacturing industries and construction |
| | Energy industries |
| | Agriculture, forestry, and fishing activities |
| | Non-specified sources |
| | Fugitive emissions from mining, processing, storage, and transportation of coal |
| | Fugitive emissions from oil and natural gas systems |
| Transportation | On-road |
| | Railways |
| | Waterborne navigation |
| | Aviation |
| | Off-road |
| Waste | Solid waste disposal |
| | Biological treatment of waste |
| | Incineration and open burning |
| | Wastewater treatment and discharge |
| Industrial processes and product use | Industrial processes |
| | Product use |
| Agriculture, forestry, and other land use (AFOLU) | Livestock |
| | Land |
| | Aggregate sources and non-$CO_2$ emission sources on land |
| Other Scope 3 | |

The selection of the applicable sectors also depends on the reporting approach selected, as discussed in the next paragraphs. For the City of Hoboken, the applicable sectors are stationary energy, transportation, and waste.

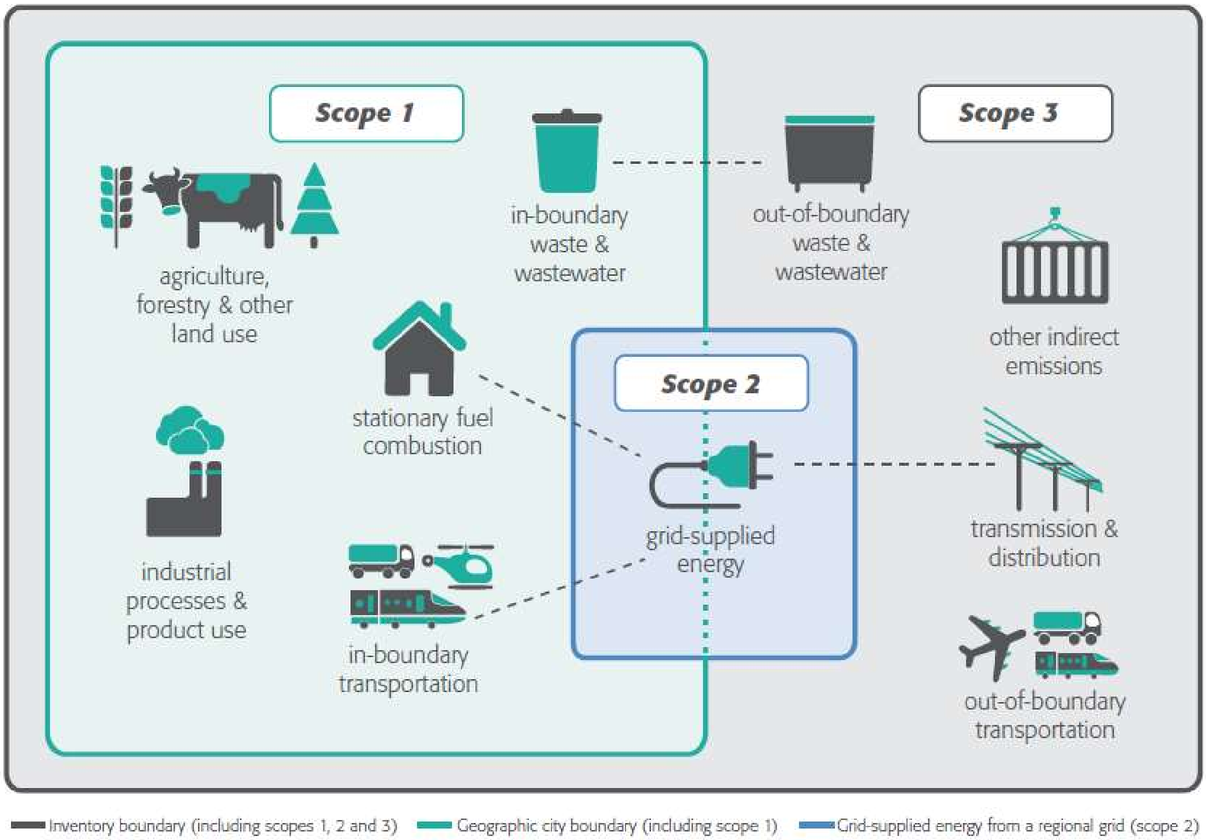
### *3.4.5 Operational Boundaries – Emissions by Scope*

GPC defines the Scope of the emission adapting the scopes framework used in WRI's GHG Protocol - Corporate Standard. GPC aggregates the emissions as Scope 1, Scope 2, or Scope 3, depending on where they are generated.

- Scope 1 (Direct emissions): GHG emissions from sources located within the city boundary.
- Scope 2 (Indirect emission): GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam, and/or cooling within the city boundary.
- Scope 3 (Indirect emission): All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

The following diagram from the GPC summarizes the aggregation of emissions by scopes.

**Figure 5: GPC Community GHG Inventory Scope of Emissions**




Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories – Figure 3.1

## 3.5 GPC Reporting Requirements

GPC requirements for reporting GHG emissions follow two complimentary approaches:

- Scopes Framework: report GHG emissions attributable to the activities taking place within the geographic boundary of the city according to the Scope 1, 2, and 3 defined above.
- City-Induced Framework: similarly to the Scope Framework, measure GHG emissions attributable to the activities taking place within the geographic boundary, according to the Scope 1, 2 and 3 definitions but report them according to two reporting levels:

  - BASIC level:
    - Scope 1 from Stationary Energy, Transportation, Waste;
    - Scope 2 from Energy and Transportation;
    - Scope 3 from exported Waste.

  - BASIC+ level:
    - All BASIC level emissions;
    - Scope 1 emissions from IPPU;
    - Scope 1 emissions from AFOLU;
    - Scope 3 emissions from Stationary Energy sources and from Transportation.

The following diagram from GPC summarizes the sectors and reporting requirements:

**Figure 6: GPC Reporting Requirements – BASIC vs. BASIC+**

| Sectors and sub-sectors | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| **STATIONARY ENERGY** | | | |
| Residential buildings | ✓ | ✓ | ✓ |
| Commercial and institutional buildings and facilities | ✓ | ✓ | ✓ |
| Manufacturing industries and construction | ✓ | ✓ | ✓ |
| Energy industries | ✓ | ✓ | ✓ |
| *Energy generation supplied to the grid* | ✓ | | |
| Agriculture, forestry, and fishing activities | ✓ | ✓ | ✓ |
| Non-specified sources | ✓ | ✓ | ✓ |
| Fugitive emissions from mining, processing, storage, and transportation of coal | ✓ | | |
| Fugitive emissions from oil and natural gas systems | ✓ | | |
| **TRANSPORTATION** | | | |
| On-road | ✓ | ✓ | ✓ |
| Railways | ✓ | ✓ | ✓ |
| Waterborne navigation | ✓ | ✓ | ✓ |
| Aviation | ✓ | ✓ | ✓ |
| Off-road | ✓ | ✓ | |
| **WASTE** | | | |
| Disposal of solid waste generated in the city | ✓ | | ✓ |
| *Disposal of solid waste generated outside the city* | ✓ | | |
| Biological treatment of waste generated in the city | ✓ | | ✓ |
| *Biological treatment of waste generated outside the city* | ✓ | | |
| Incineration and open burning of waste generated in the city | ✓ | | ✓ |
| *Incineration and open burning of waste generated outside the city* | ✓ | | |
| Wastewater generated in the city | ✓ | | ✓ |
| *Wastewater generated outside the city* | ✓ | | |
| **INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)** | | | |
| Industrial processes | ✓ | | |
| Product use | ✓ | | |
| **AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)** | | | |
| Livestock | ✓ | | |
| Land | ✓ | | |
| Aggregate sources and non-$CO_2$ emission sources on land | ✓ | | |
| **OTHER SCOPE 3** | | | |
| Other Scope 3 | | | |

✓ Sources covered by the GPC

Sources required for BASIC reporting

\+ Sources required for BASIC+ reporting

Sources required for territorial total but not for BASIC/BASIC+ reporting (*italics*)

Sources included in Other Scope 3

Non-applicable emissions

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories – Figure 4.1

The City of Hoboken selected to adopt the BASIC reporting level; therefore, all emissions from IPPU, AFOLU, and other Scope 3 are not included in the 2017 calendar year.

The following table summarizes the key information about the 2017 City of Hoboken Community Inventory:

**Table 7: 2017 City of Hoboken Community Inventory – Key Information**

| | |
|---|---|
| Reporting Protocol | World Resources Institute/Local Governments for Sustainability (ICLEI)'s Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, v1, 2014 |
| Reporting Tool | ICLEI ClearPath – Community Track - https://clearpath.icleiusa.org |
| Geographic Boundary | City of Hoboken Municipal Boundary |
| Reporting Framework | City-Induced Framework - BASIC Reporting |
| Operational Boundary | Scope 1, Scope 2, selected Scope 3 from Waste generated |
| Inventory Reporting Period | January 1 to December 31, 2017 |
| Base Year | 2017 |
| Greenhouse Gas | Kyoto Seven GHG |
| GWP Defaults | IPCC $5^{th}$ Assessment Report (AR5) |

The complete list of Sectors and Sub-sectors and Scopes reportable for the City according to the BASIC level the sources present in the City.

**Table 8: City of Hoboken – BASIC Level Reportable Sectors and Sub-sectors**

| Sector | Sub-Sectors | Scope Reported |
|---|---|---|
| Stationary Energy | Residential buildings | Scope 1, Scope 2 |
| | Commercial and institutional buildings and facilities | Scope 1, Scope 2 |
| | Manufacturing, industries and construction | Scope 1, Scope 2 |
| Transportation | On-road | Scope 1 |
| | Railways | Scope 2 |
| Waste | Disposal of solid waste generated in the city | Scope 3 |
| | Wastewater generated in the city | Scope 1 |

## 3.6 GHG Inventory Exclusions and Exceptions

The City administration provided information regarding large sources of emission located within the boundary and confirmed the following:

- no grid connected power generation facility is located within the City boundary;
- no sources of fugitive emissions from mining, processing, storage, and transportation of coal are located within the City boundary;
- no significant sources of fugitive emissions from oil and natural gas systems are located within the City boundary;
- no solid waste disposal facility is located within the City boundary;
- no biologic treatment, incineration, or open burning of waste takes place within the City boundary;

- the NHSA operates a water treatment facility located within the City boundary;
- no livestock farm or significant agricultural, forestry land use or fishing activity takes place within the City boundary;
- no significant waterborne transportation (freights, ferries) takes place, with trips originating and ending within the City boundary;
- no aviation facility is located within the City boundary

Fugitive emissions from refrigerants and halogenated gases (HFCs, PFCs, NF3 or SF6) were quantified city-wide according to average emission data at state and national level. According to the GPC, fugitive emission from refrigerants fall under the IPPU sectors as Scope 3 product use emissions. As such they are not reported under the BASIC level, but they should be reported under BASIC+. ClearPath instead quantifies fugitive emission from refrigerants as Scope 1, an approach similar to the Local Government Operations Protocol and the GHG Reporting Protocol Corporate Standard. We selected to follow ClearPath and accounted fugitive emission from refrigerants as Scope 1.

## 3.7 Inventory Data Collection Methodologies

There are several approaches that can be applied in order to collect data for a GHG inventory that can be summarized in two categories. Top-down data collection is when aggregated data for a certain source or energy usage are used to quantify the emissions from multiple generators/users of that same source. Bottom-up is instead when the data is collected from multiple users/sources of that energy or emission and then aggregated to obtain the total or city-wide emissions information. For example, city-wide data on electricity consumption could be collected top-down from the utility serving the area or bottom up by aggregating the consumption information obtained from all the users located in that area (e.g., distributing a survey). There are pros and cons for both methods, and choosing which method to use depends largely on the actual data availability for that source or type of energy. For the City of Hoboken we have used primarily a top-down approach, as discussed in the following paragraphs.

The primary methodologies utilized to collect data were the following:

- Data and information were provided by the City staff. Where data was not available for a particular source, individuals with knowledge of the activities provided an estimate based on experience.
- Aggregated energy consumption data were provided by the utility supplying the City (PSE&G).
- Aggregated transportation data were provided by the North Hudson Traffic Planning Authority (NJTPA).
- In cases when data were not available for a particular source, proxy data was researched from statistical agencies, databases, or studies at state or national level. If applicable, such data was scaled down appropriately to be used at city-wide level.

The collection methodology for each source is summarized below.

### *3.7.1 Stationary Energy – Scope 1*

The City of Hoboken receives its supply of fuel for stationary combustion primarily from the local utility, PSE&G, providing natural gas service to residential, commercial, industrial users located within the City. Other fuels commonly used for stationary combustions (heating oil, propane, etc.) are supplied by smaller distributors and it was not feasible to collect consumption information from those fragmented sources so proxy data from the United States Energy Information Administration (US EIA) was used to estimate usage of other heating fuels.

#### 3.7.1.1 Natural Gas

The local utility PSE&G provided aggregated data for the volume of natural gas supplied in calendar year 2017 to users located within the City boundary. The data was aggregated on a monthly basis, separately for residential, commercial and industrial users, and the number of accounts in each category was also provided. The number of accounts in each category was compared to demographic data for each category and they were found consistent. PSE&G was not able to confirm or provide data regarding any volume of renewable natural gas or associated environmental attributes delivered to its customers within the City boundaries; therefore, it was assumed that no biogenic gas fuel was distributed in 2017.

#### 3.7.1.2 Other Fuels for Stationary Combustion

The City administration was not able to provide an inventory of residential/commercial/industrial combustion equipment installed city-wide or any estimate of the usage of fuels other than natural gas by City users. Similarly, PSE&G was not able to provide any information on the usage of other fuels; therefore, data from the New Jersey Energy Profile by US EIA for was used as proxy. The data provide the percentage of use of the most common residential heating fuels in New Jersey[7]. The volumes of use for propane and heating oil were reverse-calculated from such percentage and the natural gas data from PSE&G. A similar approach was applied to estimate other fuels for the Commercial sector.

### *3.7.2 Stationary Energy – Scope 2*

Similarly to the natural gas supply, PSE&G is the only utility distributing the electricity to the City of Hoboken, providing service to all residential, commercial, and industrial users located within the City. PSE&G provided aggregated data for the electricity supplied in calendar year 2017 to users located within the City boundary. The data was totaled on a monthly basis, separately for residential, commercial and industrial users, and the number of accounts in each category was also provided. The number of accounts in each category was compared to demographic data for each category and they were found consistent. PSE&G also provided separately the electricity consumption by street and traffic lights located within the City boundary. Emissions for this source were calculated as a separate source. It was also confirmed that the aggregated consumption data did not include electricity used by public transportation, but it included the NHSA wastewater plant as part of the industrial users.

PSE&G was not able to confirm or provide data regarding any renewable or associated environmental attributes delivered to its customers within the City boundaries; therefore, it was assumed that no renewable electricity was distributed during calendar year 2017.

### *3.7.3 Transportation*

#### 3.7.3.1 On-Road Transportation – Scope 1

No bottom-up data was available to quantify the mobile combustion emissions from on road transportation according to fuel sales data. There are only a handful of gas stations within the City boundary, but the large number of commuters and commercial traffic in and out of the City would have made this approach inaccurate.

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[7] https://www.eia.gov/state/print.php?sid=NJ

The alternative was to use data from a traffic model specific for the area, if such data is available. In the case of Hoboken, it was possible to use the results provided by the North Jersey Regional Transportation Model- Enhanced (NJRTM-E)[8] developed by the NJTPA[9]. The NJTPA is the federally authorized Metropolitan Planning Organization for the 13-county northern New Jersey region. The NJRTM_E model was developed in 2008 and further revised in 2011, 2015, and recently revalidated in 2018. The model includes 2,712 traffic analysis zones (TAZ), of which over 1,600 of these are in the North Jersey region and specifically 12 constitute the City of Hoboken. The model includes all of New York City and Long Island, portions of southern New Jersey, portions of southern New York State, and portions of eastern Pennsylvania.

The NJRTM-E data provided by NJTPA was the result of the 2018 update of the model and while the Authority allowed the use of the data, it also cautioned that the results are still under review prior to official publication.

The option of using data from a traffic model is one of the methods recommended in the GPC. In fact, these traffic models usually apply the induced-activity approach to quantify vehicle traffic in a certain area, which is consistent with the GPC. The parameters measuring the transportation activity are the vehicle miles traveled (VMT) calculated for assigned categories of vehicles (passenger cars, light trucks, bus, etc.) and corresponding fuel usage. The model includes default fuel consumption and GHG emissions factors used to calculate the fuel usage, fuel per mile, GHG emissions, etc. by each vehicle category in each TAZ.

Traffic data are estimated from surveys, sample traffic monitoring, etc. then modeled and projected to cover larger areas and longer period of times.

According to the GPC induced-activity approach, all trips that begin, end, or are fully contained within the city (excluding pass-through trips) are included. Within-boundary trips are accounted 100 percent. Pass-through trips, i.e., trips that start and end outside of the boundary are not accounted for: they are not considered induced by the City because the source and destination are outside of it. Transboundary trips, whether incoming or outgoing, are accounted for at 50 percent of the distance traveled. Of that 50 percent distance, the portion outside of the boundary should be accounted for as Scope 3, as trans-boundary transportation, but this is not required under BASIC reporting. Because the NJTPA data provided does not show information on the individual trip distance of travel modeled and given the small area of the City of Hoboken, it is possible that this approach overestimates the Scope 1 emissions for transboundary trips by including a significant share of travel that should be reported as Scope 3.

The NJRTM-E model includes a large number of vehicle categories, each one modeled separately for each TAZ. The categories were aggregated according to the following table in order to streamline the data input in ClearPath.

[8] https://www.njtpa.org/data-maps/modeling/travel-demand-modeling
[9] https://www.njtpa.org/home

**Table 9: NJRTM-E Vehicles Categories**

| NJRTM_E Vehicle Category | First Environment - ClearPath Input Category |
|---|---|
| Combination Long-haul Truck | Heavy Trucks |
| Combination Short-haul Truck | |
| Single Unit Long-haul Truck | Medium Trucks |
| Single Unit Short-haul Truck | |
| Refuse Truck | |
| Motor Home | |
| Light Commercial Truck | Light Commercial Truck |
| Intercity Bus | Intercity Bus |
| Transit Bus | Transit Bus |
| School Bus | School Bus |
| Passenger Truck | Passenger Truck |
| Passenger Car | Passenger Car |
| Motorcycle | Motorcycle |

#### 3.7.3.2 Railway Transportation – Scope 2

In accordance with the GPC, only emissions from direct combustion of fossil fuels incurred during the length of railway transit within the city boundary for railway lines that have stops in the city boundary should be reported as Scope 1. Because of the geographic location of the railway systems in Hoboken, a very short distance (~0.5 miles) of the NJ Transit commuter rail pertinent to the Hoboken Terminal is included in the City boundary. Similarly, the NJ Transit Light Rail connecting North Bergen with Jersey City runs along the western border of the City for a distance estimated at 2.5 miles. By reviewing NJ Transit modes information from their website and energy and ridership data from the Federal Transit Administration[10] (NTD), it was determined that these modes of transportation actually use electric propulsion. As such, Scope 1 emissions for railway transportation were not quantified; but the information, data sources, and approach described above were used to quantify Scope 2 emissions from electricity consumed for railway transportation.

### *3.7.4 Waste – Wastewater Treatment – Scope 1*

North Hudson Sewerage Authority (NHSA) operates a wastewater treatment facility located on Adams Street on the northern end of the Hoboken territory. This facility serves the communities of Hoboken, Union, and Weehawken, collecting sewer and wastewater for treatment and disposal.

The NHSA provided information regarding the volume of water treated annually, the volume discharged, the treatment process as well as the population served by the Adams Street facility.

[10] https://www.transit.dot.gov/ntd/ntd-data

### *3.7.5 Waste – Solid Waste Disposal – Scope 3*

The City staff provided data and information about the quantity of both residential and commercial waste collected for disposal throughout the City during calendar year 2017 and the modalities of disposal. No information was available regarding the collection and disposal of construction and demolition waste.

### *3.7.6 Fugitive Emissions – Scope 1*

First Environment was unable to obtain sufficient information regarding the possible sources of fugitive emissions such as air conditioning equipment, certain type of fire extinguishing systems, and electrical equipment. Fugitive emissions from refrigerants and halogenated gases (HFCs, PFCs, NF3 or SF6) were quantified city-wide according to average GHG emission data from EPA[11] at national level, appropriately scaled according to the City population data. The same approach was applied by the state of New Jersey for the 2016 state-wide GHG inventory.

[11] https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016

# 4. Emissions Quantification Methodologies

GHG emissions are calculated applying the appropriate methodologies from:

- WRI/ICLEI Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), Version 1, 2014.

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 GPC methods.

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

## 4.1 Scope 1 Emissions

### *4.1.1 Stationary Energy – Natural Gas*

Emissions were calculated by multiplying the total volume of natural gas used 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 $tCO_2e$ by applying the appropriate GWP factor for each GHG from IPCC AR5.

### *4.1.2 Stationary Energy – Heating Oil, Propane*

Emissions were calculated by multiplying the total volume of each fuel used 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 applying the appropriate GWP factor for each GHG from IPCC AR5.

### *4.1.3 Transportation – On-road*

GHG emissions were calculated in ClearPath according to the "On-Road factor" method. For each vehicle category identified, the model requires the VMT/year and a set of GHG emission factors ($CO_2$, $CH_4$, and N2O) measured in g/mile. The VMT and emission factors were provided by the NJRTM-E model results; the fuel is assigned by vehicle category.

The results of these calculations in metric tonnes of $CO_2$, $CH_4$, and $N_2O$ emissions were converted to $tCO_2e$ by applying the appropriate GWP factor for each GHG from IPCC AR5.

### *4.1.4 Wastewater Generated in the City*

GHG emissions were calculated in ClearPath by quantifying the $N_2O$ emissions from discharging the effluent to a waterway. Because the daily load of nitrogen data was not available for the total volume of effluent discharged, the alternative method of estimating it according to the population served was applied. The NHSA facility does not have a nitrification/denitrification treatment; therefore, it was excluded in the calculator.

The emission result in $tN_2O$ was converted to $tCO_2e$ by applying the appropriate GWP factor for $N_2O$ from IPCC AR5.

Scope 2 emissions from electricity consumption by the wastewater facility are included in the aggregated Industrial Use quantified under Stationary Energy.

## 4.2 Scope 2 Emissions

### *4.2.1 Stationary Energy*

Location-based electricity GHG emissions were calculated according to multiplying the total electricity consumption in MWh by residential/commercial/industrial users, 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[12].

| 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 $tCO_2e$ by multiplying for the appropriate IPCC AR5 GWP factor for each GHG.

An equivalent calculation was performed to quantify "market-based electricity emissions." PSE&G was not able to provide information about any direct supply of electricity from dedicated sources, or about any contractual instruments that would convey specific emissions rates for the purchased electricity, so the market-based electricity GHG emissions were considered equivalent to the location-based electricity GHG emissions.

### *4.2.2 Transportation – Railways*

Location-based electricity GHG emissions were calculated from the estimated total electricity consumption in MWh by the railway system located and with railway stops within the city boundary. 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 were used in the calculator. The electricity use, VMT, and passenger boardings were estimated from NJ Transit publicly available data and from the NTD databases[13] for energy use and ridership for public transit agencies.

## 4.3 Scope 3 Emissions

In accordance with the BASIC reporting level, city-wide Scope 3 emissions were quantified only for waste generated in the City but disposed of outside of the City boundary.

[12] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid
[13] https://www.transit.dot.gov/ntd/ntd-data

### 4.3.1 *Disposal of Solid Waste Generated in the City*

There is no solid waste disposal facility located within the City boundary; therefore, the emissions associated with the disposal are quantified as Scope 3. The City provided data for the total weight of solid waste collected in 2017 within the City boundary; single stream recycled waste was excluded from the total tonnage. The GHG emissions were calculated in ClearPath applying a default municipal solid waste characterization and equation SW.4.1 of the GPC. Accurate information about the disposal location was not available; therefore, no assumptions were made about the presence of GHG reduction measures at the landfill (e.g., methane collection and flaring). The emissions from collection and transportation of the waste were not estimated.

# 5. GHG Inventory Quantification Results

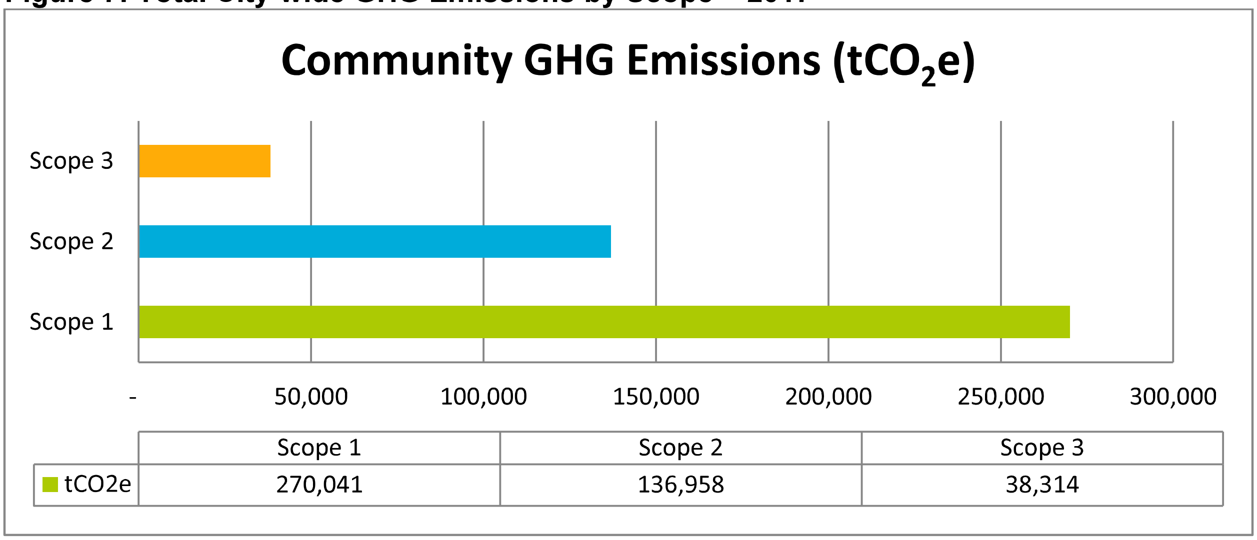
## 5.1 Total GHG Emissions

Total city-wide emissions for calendar year 2017 were 445,313 $tCO_2e$, including the following contributions by Scope:

**Table 10: Total City-wide GHG Emissions by Scope – 2017**

| GHG Emissions | $tCO_2e$ |
|---|---|
| Scope 1 | 270,041 |
| Scope 2 | 136,958 |
| Scope 3 | 38,314 |
| **Total** | **445,313** |

**Figure 7: Total City-wide GHG Emissions by Scope – 2017**

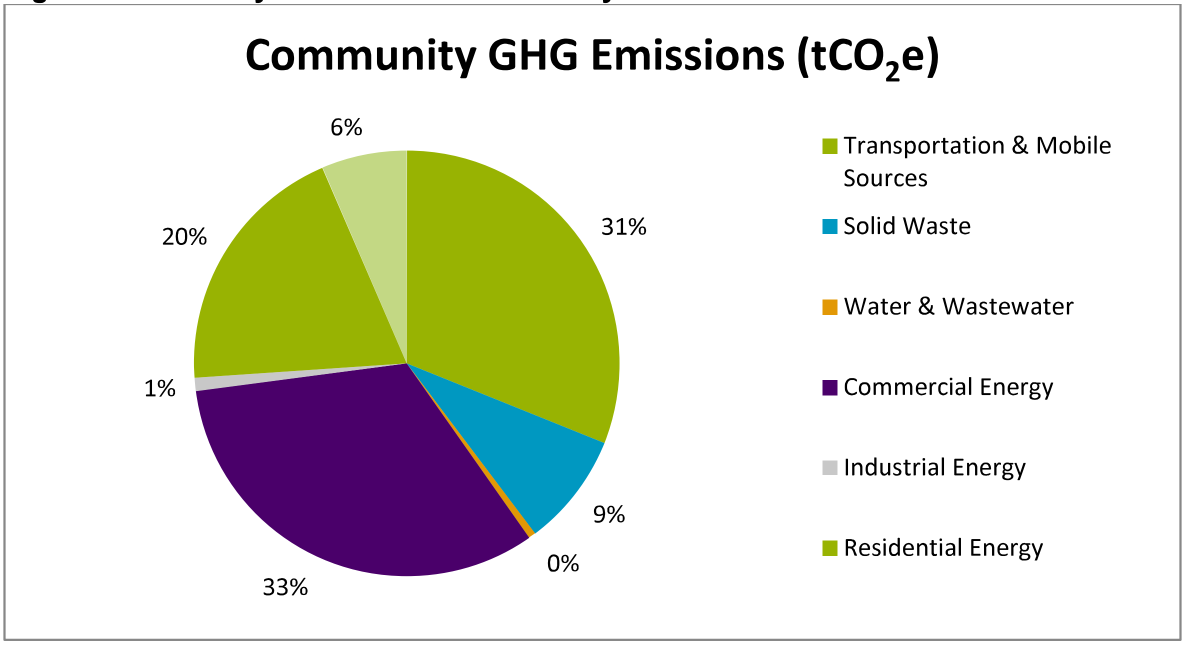



The break down by Sector in the following table and diagram:

**Table 11: Total City-wide GHG Emissions by Sector – 2017**

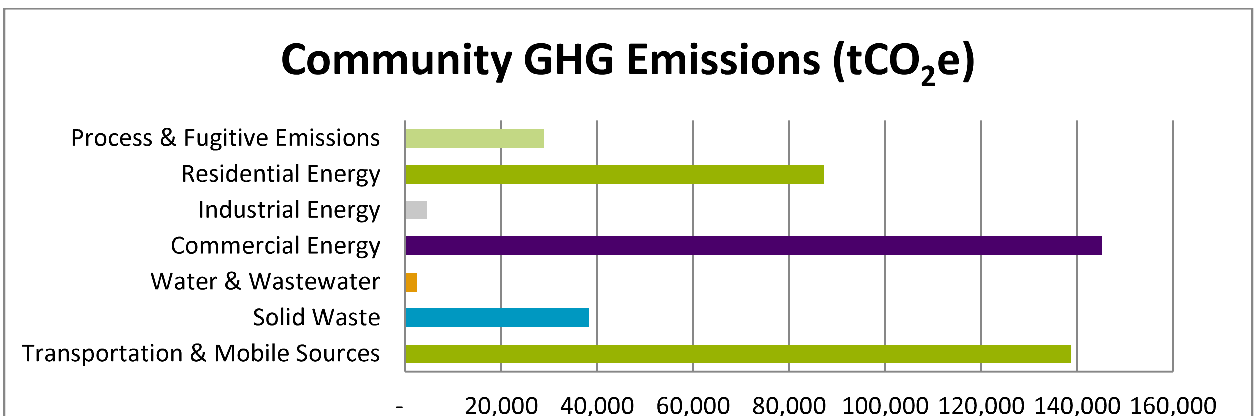
| Sector | GHG Emissions ($tCO_2e$) |
|---|---|
| Transportation & Mobile Sources | 138,768 |
| Solid Waste | 38,314 |
| Water & Wastewater | 2,457 |
| Commercial Energy | 145,239 |
| Industrial Energy | 4,441 |
| Residential Energy (including Street Lights) | 87,260 |
| Process & Fugitive Emissions | 28,833 |
| **Total** | **445,313** |

**Figure 8: Total City-wide GHG Emissions by Sector – 2017**




And in bar-diagram:

**Table 12: Total City-wide GHG Emissions by Sector – 2017**




| | Transportation & Mobile Sources | Solid Waste | Water & Wastewater | Commercial Energy | Industrial Energy | Residential Energy | Process & Fugitive Emissions |
|---|---|---|---|---|---|---|---|
| GHG Emissions (tCO2e) | 138,768 | 38,314 | 2,457 | 145,239 | 4,441 | 87,260 | 28,833 |

## 5.2 Scope 1 GHG Emissions

The City Total Scope 1 Emissions were quantified as 270,041 $tCO_2e$, including the following specific GHG contributions:

### Table 13: Scope 1 GHG Emissions

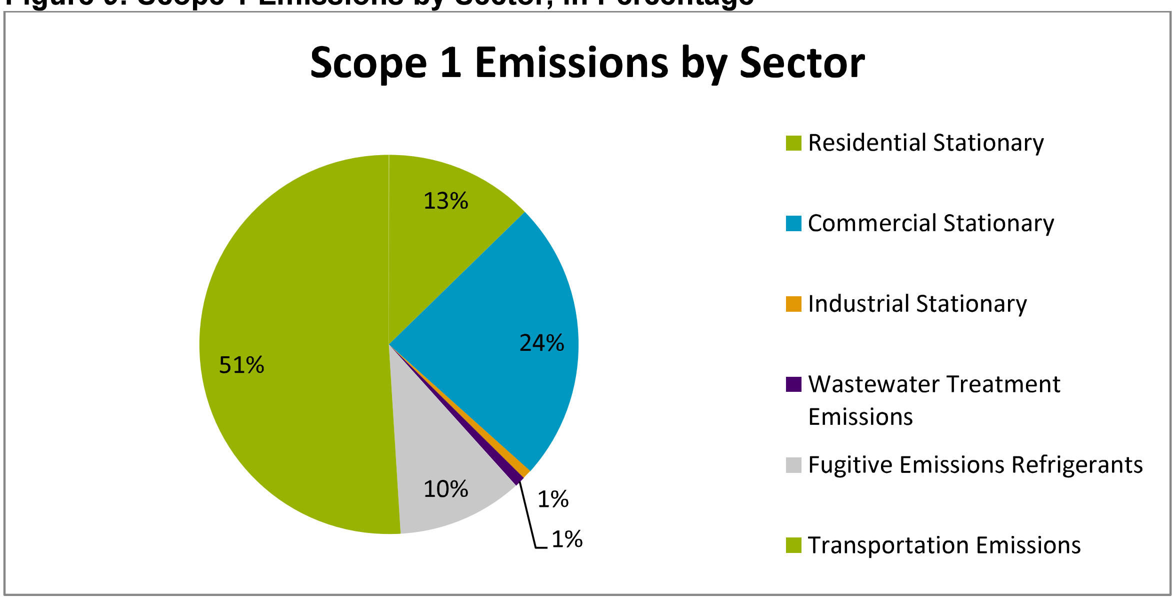
| Greenhouse Gas | t GHG | t $CO_2e$ |
|---|---|---|
| Carbon Dioxide ($CO_2$) | 266,363.16 | 266,363 |
| Methane ($CH_4$) | 14.06 | 394 |
| Nitrous Oxide ($N_2O$) | 12.39 | 3284 |
| | **Total** | **270,041** |

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

### Table 14: Scope 1 Emissions by Sector - (tCO2e)

| Sector | GHG Emissions ($tCO_2e$) |
|---|---|
| Residential Stationary | 34,281 |
| Commercial Stationary | 64,613 |
| Industrial Stationary | 2,145 |
| Wastewater Treatment Emissions | 2,457 |
| Fugitive Emissions Refrigerants | 28,833 |
| Transportation Emissions | 137,712 |
| **Total** | **270,041** |

### Figure 9: Scope 1 Emissions by Sector, in Percentage




The results highlight the predominance of Transportations the major source of GHG emissions. Scope 1 emissions from buildings and facilities (residential, commercial, industrial) rank as the second largest source followed by fugitive emission from refrigerants and halogenated gases.

## 5.3 Scope 2 GHG Emissions

The City Total Scope 1 Emissions were quantified as 136,958 $tCO_2e$, including the following specific GHG contributions:

**Table 15: Scope 2 GHG Emissions**

| Greenhouse Gas | t GHG | t $CO_2e$ |
|---|---|---|
| Carbon Dioxide ($CO_2$) | 136,957.38 | 136,957 |
| Methane ($CH_4$) | 0.009 | 0.25 |
| Nitrous Oxide ($N_2O$) | 0.002 | 0.43 |
| | **Total** | **136,958** |

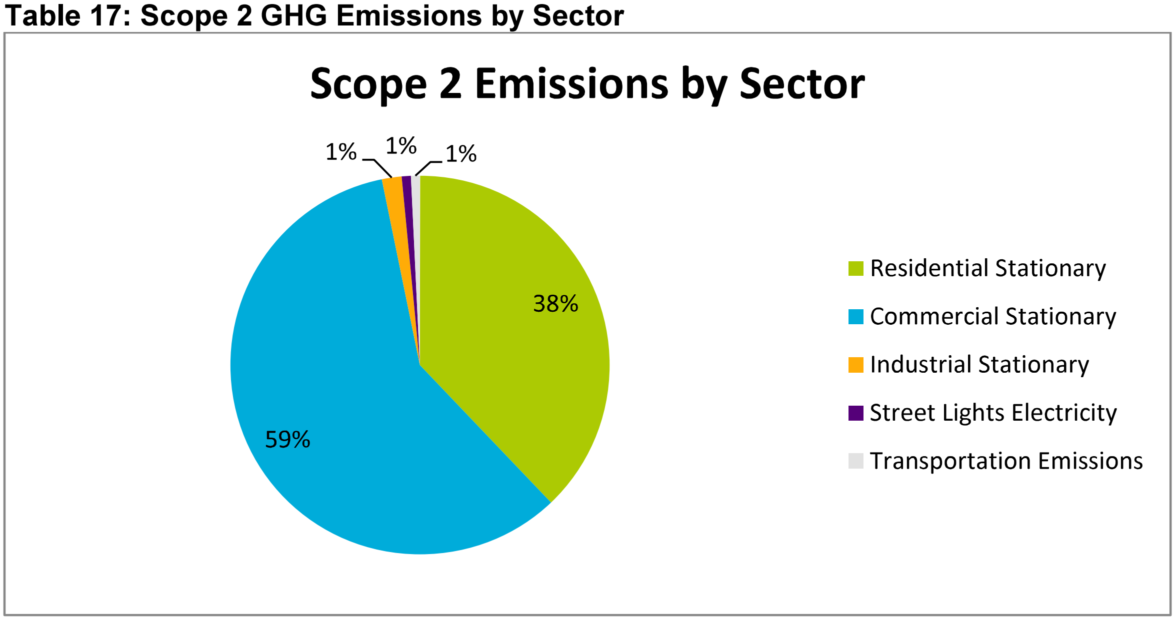
The distribution of Scope 2 emissions by sector is shown in $tCO_2e$ and in percentage in the charts below.

**Table 16: Scope 2 GHG Emissions by Sector**

| Sector | GHG Emissions ($tCO_2e$) |
|---|---|
| Residential Stationary | 51,898 |
| Commercial Stationary | 80,627 |
| Industrial Stationary | 2,296 |
| Street Lights Electricity | 1,081 |
| Transportation Emissions | 1,056 |
| **Total** | **136,958** |

The results show that residential and commercial electricity consumption are responsible for the majority of the Scope 2 emissions and actions to reduce GHG emissions should prioritize the reduction of energy consumption by these sectors.

**Table 17: Scope 2 GHG Emissions by Sector**



## 5.4 Scope 3 GHG Emissions

The Scope 3 emissions were reported only for the disposal of waste generated by the City, in accordance with the BASIC requirements. ClearPath estimated the amount of methane ($CH_4$) emissions generated by the organic decomposition of solid waste in a landfill, then converted to $tCO_2e$.

**Table 18: Scope 3 GHG Emissions**

| Greenhouse Gas | t GHG | t $CO_2$e |
|---|---|---|
| Carbon Dioxide ($CO_2$) | 0 | 0 |
| Methane ($CH_4$) | 1,368.36 | 38,314 |
| Nitrous Oxide ($N_2O$) | 0 | 0 |
| | **Total** | **38,314** |

GHG emissions from solid waste disposal represent a significant share of the City-wide emissions. These could be mitigated by reducing at the source the total amount of solid waste sent to landfill (the City already has a single stream recycling program) or by increasing the separate collection of organic waste. Additional actions could focus on the disposal site(s) ensuring that GHG emission are captured and destroyed (methane flaring) or better yet converted in useful renewable energy (electricity or pipeline grade natural gas).

The following paragraphs detail the sources of GHG emissions in each sector, identifying the contribution.

## 5.5 Stationary Energy Emissions

The City-wide emission from stationary energy, including both Scope 1 (stationary combustion) and Scope 2 (electricity consumption) were quantified as 236,941$tCO_2e$.

The contribution by each sub-sector in the following table shows the predominance of emission by commercial energy, followed by residential.

| Stationary Energy (Scope 1, Scope 1) | GHG Emissions ($tCO_2e$) |
|---|---|
| Residential Stationary | 51,898 |
| Commercial Stationary | 80,627 |
| Industrial Stationary | 2,296 |
| Street Lights Electricity | 1,081 |
| **Total** | **135,902** |

The overall contribution from each Scope is shown in the table below which demonstrates that emissions from electricity are higher than those from fuel combustion:

**Table 19: Stationary Energy by Scope**

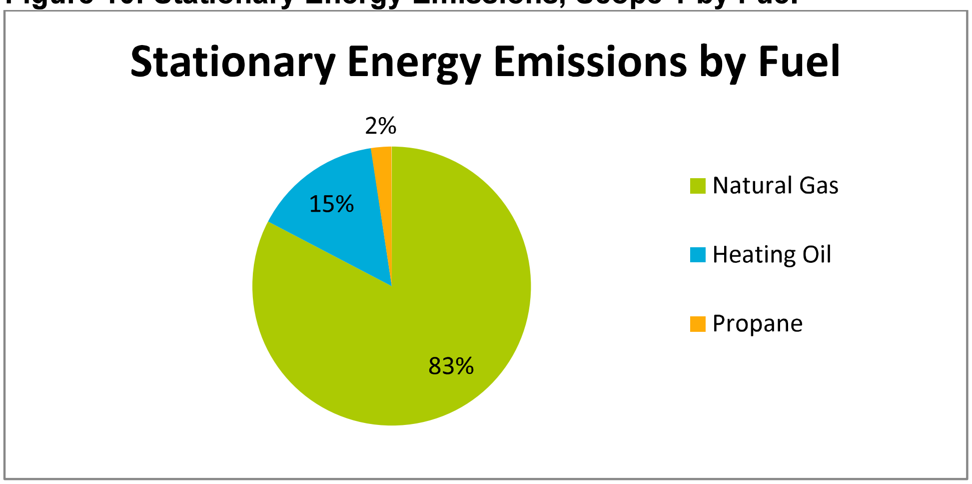
| Stationary Energy | GHG Emissions ($tCO_2e$) |
|---|---|
| Stationary Energy Combustion (Scope 1) | 101,039 |
| Stationary Energy Electricity (Scope 2) | 135,902 |
| **Total** | **236,941** |

For the stationary combustion component (Scope 1), the contribution by the three fuels modeled is shown in the following table and diagram, showing the predominance of natural gas.

**Table 20: Stationary Energy Emissions – Scope 1, by Fuel**

| Stationary Energy By Fuel | GHG Emissions ($tCO_2e$) |
|---|---|
| Natural Gas | 83,506 |
| Heating Oil | 15,115 |
| Propane | 2,418 |
| **Total** | **101,039** |

**Figure 10: Stationary Energy Emissions, Scope 1 by Fuel**




## 5.6 Transportation Emissions – On-Road

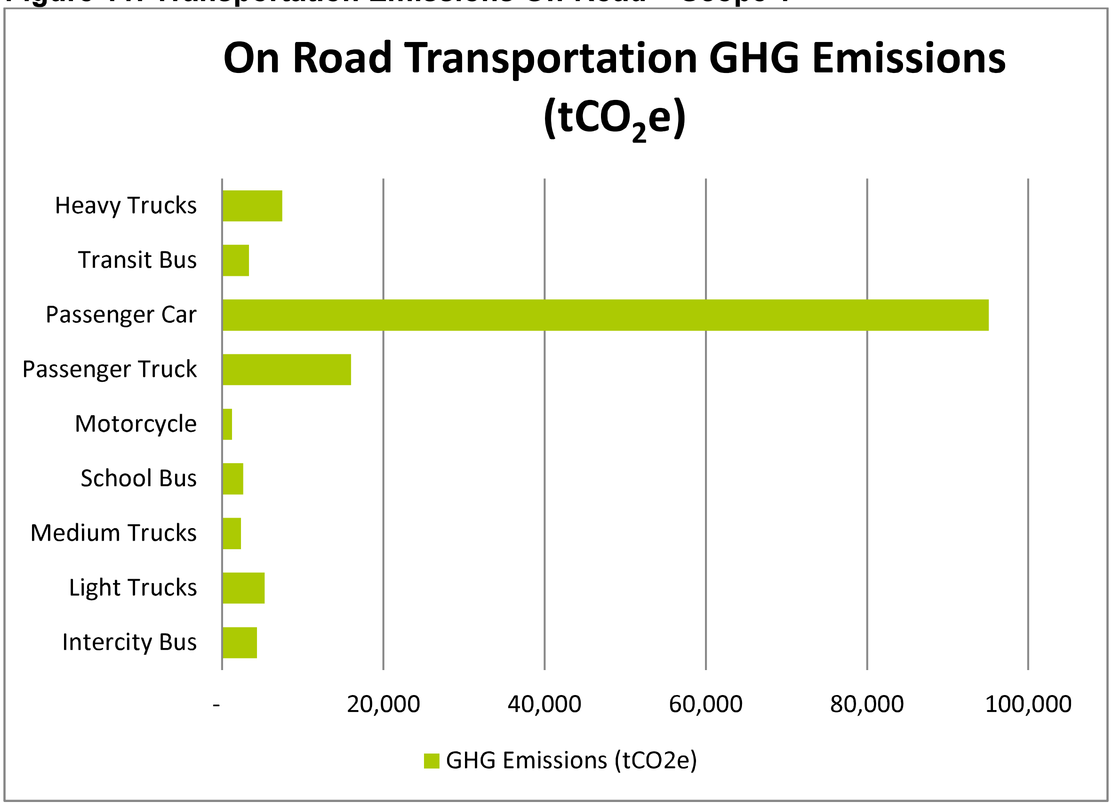
The mobile combustion emissions by city-wide on-road transportation were quantified as 137,712 $tCO_2e$. The total emissions can be broken down according to the following table:

**Table 21: Transportation Emissions On-Road – Scope 1**

| On Road Transportation | Fleet On-Road VMT (miles) | GHG Emissions ($tCO_2e$) |
|---|---|---|
| Intercity Bus | 2,995,003 | 4,312 |
| Light Trucks | 9,645,718 | 5,292 |
| Medium Trucks | 2,033,878 | 2,354 |

| On Road Transportation | Fleet On-Road VMT (miles) | GHG Emissions ($tCO_2e$) |
|---|---|---|
| School Bus | 1,816,969 | 2,616 |
| Motorcycle | 3,914,670 | 1,229 |
| Passenger Truck | 29,185,664 | 16,013 |
| Passenger Car | 232,781,836 | 95,112 |
| Transit Bus | 2,319,696 | 3,340 |
| Heavy Trucks | 3,493,578 | 7,445 |
| **Total** | **288,187,012** | **137,712** |

**Figure 11: Transportation Emissions On-Road – Scope 1**




The detailed breakdown by sources indicates passenger car activity is by far the largest source of transportation emissions. Even considering a potential overstatement of the VMT due to the induced-activity approach and the contribution from the portion of transboundary travel that should be accounted for as Scope 3 emissions, passenger vehicle traffic should definitely be the focus of any climate mitigation strategy considered by the City.

## 5.7 Transportation Emissions – Railway

The GHG emissions associated with railway transportation within the City were quantified assuming 100 percent electric propulsion and totaled 1,056 tCO2e. The contributions from the two modes quantified are shown in the table below.

**Table 22: Transportation Emissions Railway – Scope 2**

| Railway Transportation | Mode VMT (passenger-miles) | GHG Emissions ($tCO_2e$) |
|---|---|---|
| Public Transit Electricity - Light Rail | 7,858,370 | 755 |
| Public Transit Electricity - Commuter Rail | 4,713,405 | 301 |
| **Total** | **12,571,775** | **1,056** |

## 5.8 Emissions from Waste Generated in the City – Wastewater

GHG emissions from disposal of solid waste generated in the City have already been discussed in the Scope 3 Section above.

GHG emissions from sewer and wastewater treatment taking place within the City boundary are reported as Scope 1, due to the location of the NHSA facility. The emissions are the result of the nitrogen released with the effluent flow into the Hudson River. ClearPath applied nitrogen load defaults for urban sewer/wastewater to estimate the $N_2O$ emissions.

**Table 23: GHG Emissions from Wastewater Treatment in City Boundary (Scope 1)**

| Greenhouse Gas | tGHG | $tCO_2e$ |
|---|---|---|
| Carbon Dioxide ($CO_2$) | 0 | 0 |
| Methane ($CH_4$) | 0 | 0 |
| Nitrous Oxide ($N_2O$) | 9.27 | 2,457 |
| | **Total** | **2,457** |

This source of emissions could be mitigated by installing a nitrification/de-nitrification treatment in the facility, which would reduce the impact of nitrogen discharged with the effluent.

Also, currently the sludge generated by the water treatment is disposed of at a nearby facility. Depending on the volume generated, it could be processed on site in anaerobic digesters to recover the biogas and then be processed to generate electricity or renewable natural gas.

# 6. 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 achieve certain emissions reduction goals.

# 7. 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 for Community GHG emissions over the base year.

In accordance with these requirements, the City set the reduction goal of 1 percent per year. The City also set goals of achieving net-zero status for the Community GHG emissions by year 2022 and exceeding the Paris Agreement US reduction target[14] by 2027.

Because the GHG inventory is completed in 2018 based on 2017 year activity data, we assume that the first feasible year for climate actions implementation would end in 2019, with 2022 being the fourth year and the end of 2027 being nine years after the beginning of the climate action implementation.

The table below shows the reductions goals of 1 percent by the end of 2019, 4 percent by 2022, and the equivalent amount in $tCO_2e$ required to achieve the goals.

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

**Table 24: 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 | 1% | - 4,453 $tCO_2e$ |
| Year 4 | 2022 | 4% | -17,813 $tCO_2e$ |
| Year 9 | 2027 | 16% | -71,248 $tCO_2e$ |

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

# 8. GHG Emission Reduction Measures

In order to achieve the reduction goals described in the previous section, the City must identify a series of GHG emission reduction measures necessary to achieve such goals within the established timeline. The analysis of the City-wide energy consumption and GHG emission sources performed to conduct the inventory provides a basis to conduct an informed selection of potential emission reduction strategies. These measures will have to be compatible with the Community activities, targeting as much as possible the largest sources of emissions where the most significant reductions could be achieved. This should be accomplished while considering financial constraints and achieving the best balance between cost and benefits.

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

The review of the GHG emissions inventory results included in the previous paragraphs highlighted that the largest contributions were identifiable in the emissions from passenger vehicles in the transportation sector and the residential/commercial stationary energy.

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:

| Emission Reduction Measure | Target Scope and Sector | Sustainable Jersey Action |
|---|---|---|
| Making Hoboken Electric Vehicle Friendly & Implementing EV Charging Station | Scope 1 – On-Road Transportation | Yes |
| Making Hoboken Solar Friendly & Implement Solar Initiatives | Scope 2 – Stationary Energy in Buildings | Yes |
| Implement a Community-Led Residential Solar Purchasing Program (e.g., special solar pricing via approved solar installers) | Scope 2 – Stationary Energy in Buildings | Yes |
| Implement a Community-Led Commercial Solar Purchasing Program (e.g., special solar pricing via approved solar installers) | Scope 2 – Stationary Energy in Buildings | Yes |
| Implement a general residential outreach focused on Home Performance Energy Star and Comfort Partners | Scope 1, Scope 2 – Stationary Energy in Buildings | Yes |
| Implement a commercial outreach focused on Direct Install Program for local businesses within 2.5 year of application submission. | Scope 1, Scope 2 – Stationary Energy in Buildings | Yes |
| Improve Bicycle Transit Infrastructure | Scope 1 – On-Road Transportation | No |
| Increase HOP Transit Frequency-Switch to CNG | Scope 1 – On-Road Transportation | No |

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 2019-2029 period, allowing the City to develop the best implementation strategy to maximize the benefits while distributing the costs of deploying each measure over the target period.

## 8.1 Making Hoboken Electric Vehicle Friendly and Implementing EV Charging Station

The action consists of several of measures aimed at increasing the penetration of electric vehicles (EV) in the mix of vehicles driven by Hoboken residents as well as drivers from other jurisdictions traveling within the City boundaries.

**Table 25: Electric Vehicle Friendly Action Measures**

| | **Action** |
|---|---|
| A1 | Amend the zoning ordinances to include EV Supply Equipment and EV charging stations as a permitted accessory use |
| A2 | Adopt a PEV ordinance to include regulations and design standards for EVSE, EV charging and parking |
| A3 | Required First responders' On-line training on EV Supply Equipment |
| A4 | Awareness event - Host an EV awareness event for the community |
| A5 | Provide public access to EV Change Stations |

First Environment reviewed the City vehicle registration records for 2017 and estimated that the number of hybrid/electric vehicles registered within the City boundary is only 45 out of 21,180, or 0.22 percent. The projected average for 2018 in the US is 1.75 percent, but there are areas such as California where the concentration is much higher: 7.50 percent statewide and 38 percent for communities such as Palo Alto.

The ClearPath planning module includes a model simulating the effects of implementing policies and measures favoring the adoption of EV. The climate action was assumed to gradually increase the share of EV in the passenger vehicles circulating in Hoboken, reaching 15 percent over the next 10 years, by the end of 2028. The model estimated the decrease in carbon emissions for the passenger car fleet as much as 1,390 $tCO_2e$ per year (approximately 0.31 percent of the baseline), which assumes that the increase in EV share keeps growing at the 1.5 percent/year rate assumed.

| EV Circulation Share Target | Target Year | Emission Reduction ($tCO_2e$/year) | Percentage Reduction to Baseline |
|---|---|---|---|
| 15% | 2028 | -1,392 | - 0.31% |

## 8.2 Implementation of Solar Initiatives – Community Led Solar Program

The action recommends the adoption of policy facilitating the access by the community to renewable electricity generated by solar energy. This could include both streamlining the procedures, permitting, and financing for solar PV systems, the pre-qualification of approved installers and contractors, but also exploring new mechanisms such as the Community Solar Programs. These are innovative approaches designed to allow residents of, for example, dense urban areas, where installation of solar PV system is problematic or ineffective, to gain access to renewable electricity by participating in a solar PV project developed by third parties installed in a more appropriate location. The participation could be either through purchase of shares of the PV projects (such as kW of installed capacity) or by buying a certain allocation of electricity production on a periodic basis. In both cases, any excess electricity besides the monthly usage by the user is sold on the market, potentially generating revenue. In case of deficit, the user is billed for the difference by the utility. A similar approach is when the City itself becomes the developer of the solar PV project and then offers to its residents to opt-in and receive the renewable electricity through various participation mechanisms similar to the ones previously described. In these cases, there are still a few regulatory hurdles before they can be implemented in New Jersey, beginning with the requirements for to allow virtual net-metering.

Nonetheless, the feedback received during the Community meetings held during the development of the GHG Inventory and Climate Action Plan clearly highlighted the difficulties in accessing affordable and effective solar energy as a major hurdle that the Community would like to overcome. It was also communicated how previous efforts by the City administration to favor residential installation of solar PV systems had not met much success due to the nature of the dense urban environment characterized by small roof areas that are inefficient for solar PV installation.

Based on this feedback, it was decided to model a program that would aggressively target an innovative approach to solar PV energy. It was assumed that the City would implement two programs, one for residential and the other for commercial users, building participation in each program at the rate of one megawatt (MW) each year, for five years, until two 5 MW Community Solar projects are completed. Under these assumptions, the ClearPath planning module estimated potential reduction of 515 $tCO_2e$/ MW installed for each program, reaching the maximum benefit of 2,575 $tCO_2e$ annual reduction for each program after five years.

The table below shows the estimate of electricity production and GHG reduction based on the baseline year electricity consumption.

| Renewable Energy Installed Capacity | Renewable Energy Production (kWh/Year) | Emission Reduction ($tCO_2e$/year) | Percentage Reduction to Baseline |
|---|---|---|---|
| 1 MW | 1,500,000 | -515 | -0.12% |
| 5 MW | 7,500,000 | -2,575 | -0.60% |
| 10 MW | 15,000,000 | -5,150 | -1.2% |

## 8.3 Buildings Retrofit – Residential and Commercial

The GHG inventory results highlighted that besides transportation, the largest contribution to the community emissions are generated from stationary energy used in residential and commercial buildings. This includes both emissions from stationary combustion and electricity consumption. This is not surprising given the dense urban environment of the City and the absence of major industrial or process sources of emissions.

As discussed in the municipal GHG inventory report, the City government 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. The upgrades include improvements to buildings' heating, air conditioning, and electrical equipment. Heating, ventilation, and air conditioning (HVAC) equipment represents 30 to 40 percent of commercial building energy use. Additional energy savings can be achieved by improving the building insulation and envelope. Building inspections and energy audits can help identify areas of improvement and better plan the upgrades and costs.

The climate action proposed would entail a City outreach program combined with policies aimed at informing, facilitating, and incentivizing energy efficiency analysis and retrofits in residential and commercial properties. The goal would be to gradually improve the thermal and electrical performance of the City buildings inventory over a number of years. The ClearPath planning tool provided a calculator modeling two separate measures: one for residential outreach and education, the other for commercial properties retrofits. In both cases, the model assumes default performance improvements in kWh/sqft and therms/sqft when the measures are implemented. The calculator also assumes an annual quantity of residential and commercial space being affected by the program. For the residential program, it was assumed that 3,000 households participate in the program each year (Hoboken currently counts 24,812 households). For the commercial property, it was assumed that 500,000 sqft would be retrofit each year, out of the current 6,700,000 sqft of commercial space present in the City. The program is modeled to begin in 2020 and continue until 2029; by then, the majority of the households and commercial properties will have been included in the program.

The expected results are detailed in the table below. The annual reduction is calculated for the share of households or commercial space joining the program that year; therefore, year after year the savings add up, reaching approximately 5.5 percent GHG emissions reduction compared the baseline inventory for residential and 1.3 percent for commercial space.

| Energy Efficiency Program | Property affected /year | Thermal Energy Savings (therms/year) | Electricity Savings (MMBtu/Year) | Emission Reduction ($tCO_2e$/year) | Annual Reduction to Baseline |
|---|---|---|---|---|---|
| Residential Property | 3000 households | 112 th/home/year | 619 kWh/home/year | -2,425 | -0.54% |
| Commercial Property | 500,000 sqft | 0.013 therms/sqft | 1.3 kWh/sqft | - 569 | -0.13% |

## 8.4 Improvement of Bicycle Infrastructure

The City of Hoboken has already built a significant bicycle lane and paths infrastructure extending for eight miles; the system also includes a bike share program. This was started in 2015 and counts 20,000 members with 29 stations and 250 bicycles available for sharing. There were no data available regarding the current rate of use of the bicycle infrastructure so it was decided to model a system improvement measure, using the average defaults provided by ClearPath for a dense urban area. The model assumes an existing bicycle infrastructure and quantifies the potential emissions reductions according to a moderate improvement of the mode share. The increased use of the bicycle infrastructure leads to a reduction of use of other modes (passenger cars, transit) modeled in the transportation emission module, resulting in a reduction of overall emissions. The results are showed in the following table.

| Energy Efficiency Program | Project Timeline | Annual Emissions Reduction ($tCO_2$/year) | Annual Percentage reduction to Baseline | Annual Percentage reduction at end of 10 years |
|---|---|---|---|---|
| Bike Infrastructure | 10 years | -164 | -0.04% | -0.4% |

## 8.5 Increase City Public Transit Frequency - Low Emissions Fuel Switch

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 the 2017 records provided by the City show a fuel consumption of 20,672 gallons of fuel and estimated 206,719 miles for VMT. The reduction measure modeled consists of increasing (doubling) the transit frequency based on the recorded VMT as well as replacing or retrofitting the current gasoline vehicles with equivalent ones running on Compressed Natural Gas (CNG) fuel.

The CNG fuel emits lower volume of $CO_2$e 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 bus replacement could cost $80,000. The fuel cost savings amount to approximately $20,000/year for the current HOP fleet, according to the average market price difference of $1 per gallon of gasoline equivalent fuel and the current VMT/year. In addition, ClearPath estimated the emissions reduction that could be achieved by the change in transit mode share due to increasing the frequency or extending the routes of the HOP systems. The assumption is to double the annual VMT traveled by the buses and the default ClearPath factors were used, assuming the baseline service is located in dense urban center with fairly infrequent service (waiting time more than 50 minutes).

The overall emission reduction due to the two-fold measure is estimated as 4,555 $tCO_2$e/year, or approximately one percent of the 2017 baseline. This significant improvement is probably affected by the large contribution to emission due to passenger car travel, where the model considers that the increased frequency would attract significant mode sharing from passenger cars to public transit.

| HOP Fleet Vehicles | Emission Reduction ($tCO_2$e/year) | Emissions Reduction to Baseline | Estimated Cost | Fuel Savings ($/Year)[15] |
|---|---|---|---|---|
| 5 | 4,554 | -1.02% | $80,000/ vehicle | $20,240 |

[15] Fuel savings are calculated on the basis of the current VMT of ~ 200,000 miles. Doubling the frequency would incur in additional fuel cost, but the switch to less expensive fuel would reduce such increase.

## 8.6 Street Lights and Traffic Lights Conversion to LED

This measure is discussed in more detail in the Municipal GHG inventory and Climate Action Plan and consists of upgrading the street lights and traffic lights installed within the City boundary to advanced street light technology such as light-emitting diodes (LEDs). The measure was modeled in ClearPath for the lights operated by the City administration (a small number of lights are operated by other entities, such as Hudson County). If the measure were to be implemented by the City administration, the benefits would also benefit the Community GHG inventory and for that reason we are including it in the report. The conversion to LED can reduce street lighting 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 following results were modeled in ClearPath and match the reduction results estimated for the City municipal inventory. The results show that at Community level the emissions reductions are less significant than compared to the much smaller municipal inventory.

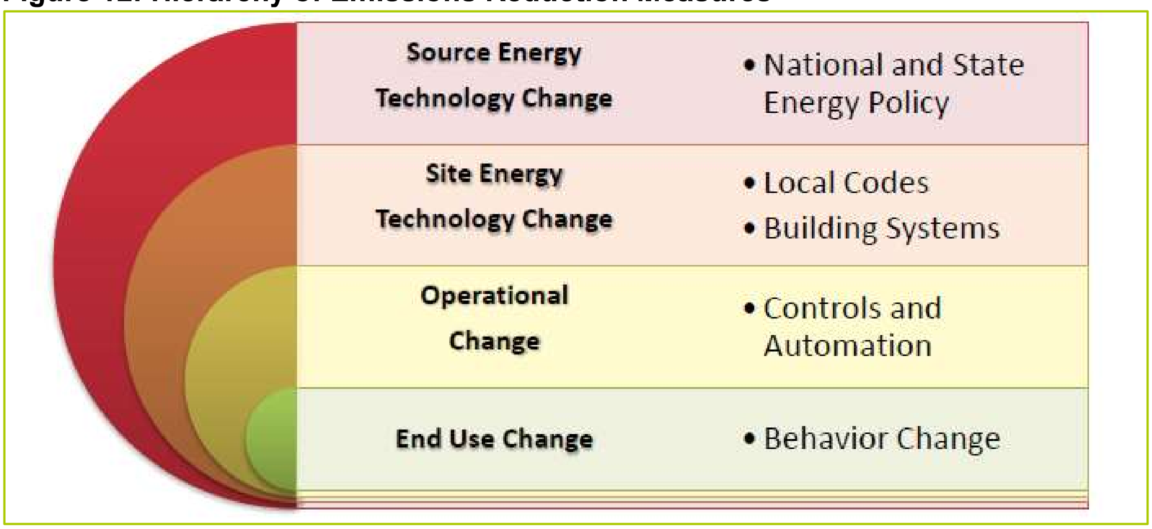
| Reduction Measure | Change Electricity Use (kWh/Year) | Emission Reduction ($tCO_2e$/year) | Percentage reduction to Community GHG Baseline |
|---|---|---|---|
| Street Lights | -1,128,300 | -388 | -0.10% |
| Traffic Lights | -104,700 | -36 | |

# 9. 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, for the Community Solar and Energy Efficiency Outreach programs 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 realistic timeline and financial 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 (e.g., upgrading a power plant), requiring more time to prepare and implement than a relatively simple building management policy setting rules on thermostat 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 26: Summary of GHG Emissions Reduction Measures**

| Reduction Measure | Expected GHG Emission Reduction ($tCO_2e$/year) | Priority | Comment |
|---|---|---|---|
| Making Hoboken Electric Vehicle Friendly & Implementing EV Charging Station | -1,392 | 1 | Medium complexity implementation;<br>Medium Cost;<br>Significant GHG emissions reduction |
| Making Hoboken Solar Friendly & Implement Solar Initiatives | -2,575 | 1 | Medium complexity implementation;<br>Low Cost;<br>Low GHG emissions reduction |
| Implement a Community-Led Residential Solar Purchasing Program (e.g., special solar pricing via approved solar installers) | | 2 | Complex implementation;<br>Cost dependent on program;<br>Significant GHG emissions reduction |
| Implement a Community-Led Commercial Solar Purchasing Program (e.g., special solar pricing via approved solar installers) | -2,575 | 2 | Complex implementation;<br>Cost dependent on program;<br>Significant GHG emissions reduction |
| Implement a general residential outreach focused on Home Performance Energy Star and Comfort Partners | -2,425 | 2 | Medium complexity implementation;<br>Medium Cost (FTE);<br>Significant GHG emissions reduction |
| Implement a commercial outreach focused on Direct Install Program for local businesses | -569 | 2 | Medium complexity implementation;<br>Medium Cost;<br>Low GHG emissions reduction |
| Improve Bicycle Transit Infrastructure | -164 | 2 | Medium complexity implementation;<br>High Cost;<br>Low GHG emissions reduction |
| Increase HOP Transit Frequency-Switch to CNG | -4,554 | 3 | Medium complexity implementation;<br>High Cost;<br>GHG emissions reduction highly dependent on behavioral change |

The priority order should also take into account the reduction goals at year 1, 4, and 9, planning the implementation of the measures in order to meet the reduction timeline while avoiding concentrating implementations in a short time span. To achieve some of the City's goals for the community, a more ambitious approach will have to be considered because of the short time frame (e.g., net zero by 2022). To demonstrate what this may mean for implementation, the data for each measure were input in ClearPath planning module and several tests were performed. The table below shows an aggressive implementation plan, reducing the time for the City to plan for the financing and implementation of the different measures but trying to maximize the reduction to achieve the Net-Zero goal planned for 2022.

**Table 27: GHG Emission Reduction Measures Implementation Timeline - Net-Zero 2022 Scenario**

| Reduction Measure | Implementation Start Year | Implementation End Year | Forecast End Year |
|---|---|---|---|
| Making Hoboken Electric Vehicle Friendly & Implementing EV Charging Station | 2019 | 2029 | 2029 |
| Making Hoboken Solar Friendly & Implement Solar Initiatives | 2019 | 2029 | 2029 |
| Implement a Community-Led Residential Solar Purchasing Program | 2020 | 2025 | 2029 |
| Implement a Community-Led Commercial Solar Purchasing Program | 2020 | 2025 | 2029 |
| Implement a general residential outreach focused on Home Performance Energy Star and Comfort Partners | 2020 | 2029 | 2029 |
| Implement a commercial outreach focused on Direct Install Program for local businesses | 2020 | 2029 | 2029 |
| Improve Bicycle Transit Infrastructure | 2020 | 2029 | 2029 |
| Increase HOP Transit Frequency-Switch to CNG | 2020 | 2029 | 2029 |

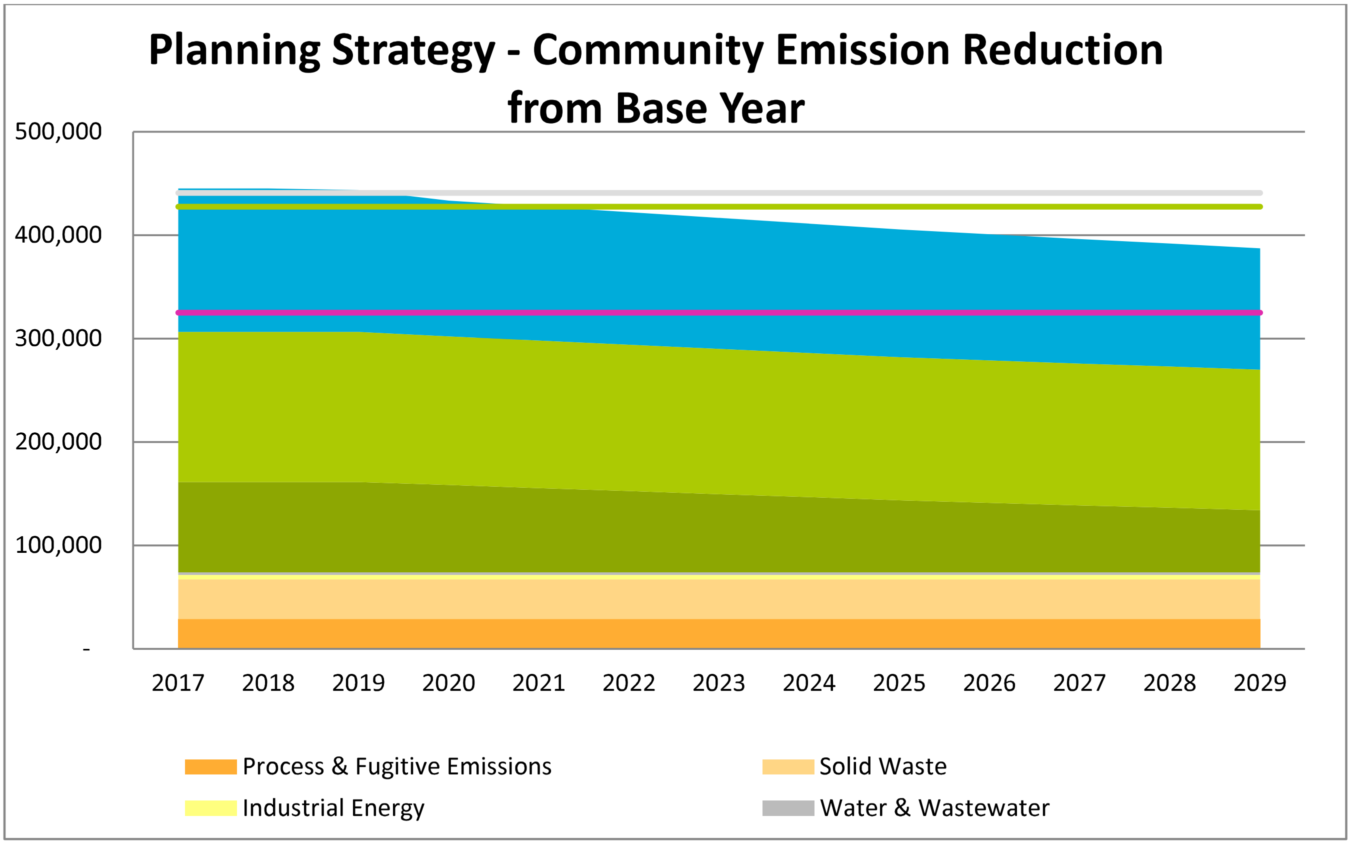
The results of the reduction measures planning and the estimate of the emission reduction are shown in the following tables and diagrams.

### Table 28: GHG Emission Reduction Plan – Net Zero 2022 Scenario

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Process & Fugitive Emissions | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 | 28,833 |
| Solid Waste | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 | 38,314 |
| Industrial Energy | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 | 4,441 |
| Water & Wastewater | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 | 2,457 |
| Residential Energy | 87,260 | 87,260 | 87,260 | 84,319 | 81,377 | 78,436 | 75,495 | 72,554 | 69,613 | 67,187 | 64,761 | 62,336 | 59,910 |
| Commercial Energy | 145,239 | 145,239 | 145,203 | 143,731 | 142,646 | 141,561 | 140,476 | 139,391 | 138,306 | 137,737 | 137,168 | 136,599 | 136,029 |
| Transportation & Mobile Sources | 138,768 | 138,768 | 137,212 | 131,323 | 129,766 | 128,210 | 126,653 | 125,096 | 123,539 | 121,982 | 120,425 | 118,868 | 117,311 |
| **Total Emissions** | **445,312** | **445,312** | **443,720** | **433,418** | **427,834** | **422,252** | **416,669** | **411,086** | **405,503** | **400,951** | **396,399** | **391,848** | **387,295** |
| Reduction to 2017 Baseline | 0 | 0.0% | -0.4% | -2.7% | -3.9% | -5.2% | -6.4% | -7.7% | -8.9% | -10.0% | -11.0% | -12.0% | -13.0% |
| 1 Year Goal | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 | 440,859 |
| 4 Year Goal | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 | 427,500 |
| 2027 - Paris Agreement -16% Baseline | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 | 374,062 |

The emissions reductions are calculated according to the 2017 baseline. The results in the table show that even if the reduction measures are implemented according to a more aggressive schedule, only the annual goals of -1 percent reduction could be achieved but it would be very difficult to achieve the Net Zero status by 2022 as well as exceeding the Paris agreement goal of -16 percent by the end of 2027. Even with the -5.2 percent reduction achieved by 2022, a large share of emissions due to stationary energy would have to be still reduced or potentially offset to obtain a Net-Zero status.

**Figure 13: GHG Emission Reduction Plan – Net-Zero 2022 Scenario**



# 10. 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.

# 11. 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.