GREENHOUSE GAS INVENTORY

CITY OF DELRAY BEACH

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RS&H

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SUMMARY

A Greenhouse Gas (GHG) Inventory is essential for understanding Delray Beach's GHG emissions. It is the first step towards honoring the City's U.S. Climate Mayors commitment to uphold the Paris Agreement, which was signed by Mayor Glickstein in 2017. It identifies the most significant emissions sources and facilitates development of goals, projects and policies to reduce them.

RS&H has prepared the first GHG emissions inventory and forecast for the City's Local Government Operations (LGO) and the community as a whole (Community).[1] This inventory establishes 2017 as the baseline for the City's GHG emissions.

Since LGO emissions are part of the community's, the LGO inventory may be regarded as a subset of the community inventory. It is included to give the City government a detailed picture of emissions it directly controls. The report also includes a business-as-usual (BAU) forecast of the community-wide emissions from the present to 2035.

Together, the inventories and forecast facilitate understanding of present and future emissions trends. They also provide information needed by staff, policy-makers and citizens as they design and implement strategic measures to reduce GHG emissions.

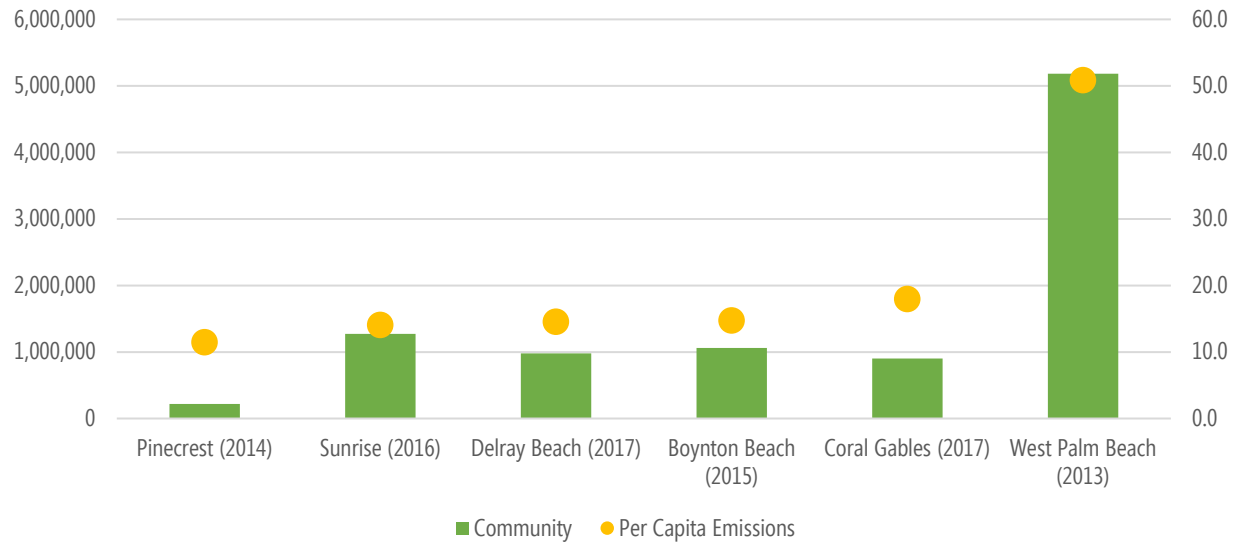
In 2017, the community's total estimated emissions were **998,446 metric tons of carbon dioxide equivalents ($mtCO_2e$)**[2], with the transportation sector contributing the largest single source (60%). The Residential and Commercial sectors also contributed significantly at 21% and 17%, respectively.

Within this community-wide total, local government operations (i.e. facilities, vehicles, and infrastructure directly owned and/or controlled by the city) were responsible for emitting **19,651 $mtCO_2e$**, with city-owned buildings and facilities contributing 66%. The city's vehicle fleet operation and city streetlights also contributed significantly to the total LGO emissions, at 20% and 9%, respectively.

[1] For ease of access and future updates, RS&H entered the inventory into ICLEI - Local Governments for Sustainability's ClearPath web-based software.
[2] CO_2e refers to carbon dioxide equivalent (CO_2e), a measure that describes how much warming a given type and amount of a greenhouse gas may cause, using the functionally equivalent amount of carbon dioxide (CO_2) as the reference.

The community's per capita emissions (about 14.5 $mtCO_2e$ / per capita) compare favorably with peer South Florida municipalities (Figure 1).[3]

FIGURE 1: GROSS AND PER CAPITA COMMUNITY GREENHOUSE GAS EMISSIONS BY MUNICIPALITY



If no actions are taken, community-wide emissions could increase by **16%** to 1,158,736 mtCO2e by 2035. This "Business-as-Usual" (BAU) forecast is based on growth factors for energy use, transportation fuel consumption, population growth, and water supply. There is great uncertainty in projecting future emissions. This forecast should be viewed as a tool for planning GHG reduction activities. The methods used to develop the BAU are described in detail in the section "Forecast Methodology", below.

To effectively reduce emissions, RS&H recommends short, medium, and long-term emissions targets based on an analysis of goals set by peer local governments, international agreements and climate science. The recommended targets are 20%, 40% and 80% reductions by 2028, 2035, and 2050, respectively, relative to the 2017 baseline.

Other recommendations to advance the City's carbon mitigation and resilience efforts include a Climate Data Management Initiative, Energy and Waste Assessments for municipal facilities, developing a Sustainability and/or Climate Action Plan and a Community Vulnerability Assessment.

[3] Comparison of gross and per capita municipal GHG emissions is useful to provide context for the City of Delray Beach's emissions. It is of limited use as a planning tool, given significant differences among cities and the emissions activities that occur within municipal boundaries.

INTRODUCTION

Delray Beach is a leader in promoting public awareness about the causes and impacts of climate change. In 2017, Mayor Cary Glickstein signed the Climate Mayor's Statement on the Paris Agreement, pledging the City to meet the goals enshrined in the Paris Agreement to limit warming to 1.5 degrees Celsius globally. This commitment builds on the City's 2014 endorsement of the Mayors Climate Action Pledge, and affirmation of support for the Southeast Florida Regional Climate Change Compact and the goals, targets and actions set forth in the Compact's Regional Climate Action plan.

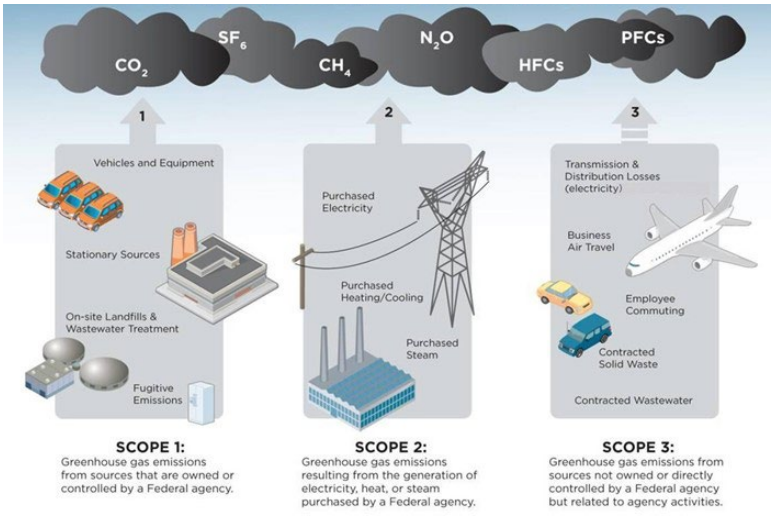
This greenhouse gas inventory supports the City's long-term efforts to reduce emissions and address climate change. It quantifies the City's contribution and establishes a starting point for measuring reductions. The inventory facilitates identification of opportunities to reduce emissions through policy, purchasing, operational efficiency and behavioral change. It is the latest in a series of efforts by the City to improve sustainability performance, reduce emissions that contribute to climate change, and improve community resilience.

This report presents estimates of GHG emissions in Delray Beach for the calendar year 2017 for each emissions-producing activity that takes place within the city jurisdictional boundary. This boundary serves as the physical limits for the inventory. This report is accompanied by an electronic version of the inventory. Created using the ClearPath web-based software developed by Local Governments for Sustainability (ICLEI), it facilitates online access and updates to the City's GHG emissions records.

The Community portion of the inventory was completed under ICLEI's U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.1, published July 2013 (Community Protocol). The Local Government Operations portion of this inventory was completed under ICLEI's Local Government Operations Protocol, (LGO Protocol) Version 1.1, published May 2010 (LGO Protocol).

GHG emissions fall into three "scopes" (Figure 2). Scope 1 emissions come directly from owned or controlled sources. Examples include emissions from burning fossil fuels in vehicles; operation of landfills or wastewater treatment facilities within jurisdictional boundaries, or fugitive emissions from HVAC or fire suppression equipment. Scope 2 emissions come indirectly from owned / controlled sources. Examples include emissions from purchased electricity in buildings, utilities and streetlights. Scope 3 emissions do not come from owned or

FIGURE 2: GREENHOUSE GAS EMISSIONS SCOPES (SOURCE: US-EPA)



controlled sources. However, they have an important relationship to government or community activities. Examples include employee commuting, contracted waste disposal or wastewater treatment occurring outside jurisdictional boundaries, and electricity transmission and distribution loses. Scope 3 emissions are not Delray Beach's immediate responsibility. However, understanding selected Scope 3 emissions sources provides a holistic view. This insight may provide opportunities for leadership in reducing GHG emissions.

This GHG Inventory includes emissions sources required by the Community and LGO protocols. For the community inventory, these include: stationary fuel use, transportation fuel use, and water and wastewater treatment, (Scope 1), electricity use (Scope 2), and waste transport and incineration (Scope 3). For the LGO inventory, they include vehicle fleet fuel use and fugitive emissions from refrigeration and HVAC equipment (Scope 1), facility and exterior lighting electricity use (Scope 2), and solid waste disposal and employee commuting (Scope 3).

In Delray Beach, as in most organizations, GHG emissions are not measured at the source. Instead, they are calculated based on activity data and emission factors. The basic equation used is*: Activity Data X Emission Factor = Emissions*. Activity data collected and provided by the City measure energy use, fuel consumption or other indicators of processes that generate emissions. Factors for emissions per unit of activity data (e.g. metric tons CO_2/kWh of electricity) are used to convert activity data into emissions quantities. Calculations involve several assumptions that are limited by the quality and availability of related data. Accordingly, emission estimates are indicators, rather than exact values. Emissions estimates should be revisited and revised over time as the quality and quantity of data changes. Use of a standard, third-party protocols, such as those used to complete this inventory, will ensure that future inventories are methodologically consistent and comparable over time, providing a reliable resource for reporting emissions and planning activities to reduce emissions.

Emissions estimates in this inventory are presented in units of metric tons of carbon dioxide equivalent ($mtCO_2e$). Because various greenhouse gases have differing global warming potentials, they are commonly converted to equivalent units of CO_2 to allow comparison of their global warming effects.

RS&H prepared a community-wide emission forecast over an 18-year time horizon from 2017 through 2035. This "Business as Usual" forecast assumes no further actions taken to control emissions. Growth factors drawn from federal, state and local government sources were used to develop the forecast. The BAU forecast is useful for comparing planned emissions reductions with increases under a BAU scenario. This is particularly important given the pace of historic and planned growth in Delray Beach, and underscores the importance of influencing the sustainability characteristics of growth in the community.

The GHG inventory provides a basis for recommended emissions reduction targets. The recommended targets are based on analysis of goals set by peer local governments, current climate science and the City's commitment to the Paris Agreement goals. Other recommendations include a Climate Data Management Initiative, Energy and Waste Assessments for municipal facilities, development of a Sustainability / Climate Action Plan, and a Community Vulnerability Assessment. These recommendations will facilitate future GHG inventory updates, as well as a comprehensive approach to developing policies and projects to mitigate and adapt to climate change.

COMMUNITY

The community-scale inventory represents the total amount of GHG emissions associated with the community within its jurisdictional boundary. This total includes emissions from municipal government operations and community activities.

Community Inventory Overview

In 2017, community-wide emissions from Delray Beach totaled **998,446 mtCO_2e**. Table 1 shows community sectors, activities, and estimated emissions included in this total. Each of these sectors and activities are defined further in the Community Inventory Data Sources and Methods section below. Figure 1 shows the percentage of the total contributed by each sector.

TABLE 1: 2013 COMMUNITY INVENTORY SECTORS, ACTIVITIES, AND EMISSIONS

Sector	Activities	Emissions (CO_2e)
Residential	Electricity consumption	206,485
	Public Authority Electricity consumption^	19
	Propane/LPG consumption	417
	Natural Gas consumption	168
Commercial	Electricity consumption	151,141
	Public Authority Electricity consumption^	16,989
	Propane/LPG consumption	NE†
	Natural Gas consumption	NE†
Industrial	Electricity consumption	235
	Public Authority Electricity consumption^	13,568
	Public Streets and Highways Electricity	1,131
	Propane/LPG consumption	NE‡
	Natural Gas consumption	NE‡
Transportation	Vehicle Miles Travelled (VMT) emissions	594,405
Water and Wastewater	Potable Water Treatment	1,730*
	Wastewater treatment – N_20 process	179
	Wastewater treatment – N_20 effluent	473
	Wastewater treatment – CH_4	22,866*
	Septic system fugitive emissions	6
Agriculture	*Not occurring in the community*	NO‡
Community-generated Waste	Solid waste generation / incineration	12,231
	Solid waste transportation	999
Process and Fugitive Emissions	*Not estimated – no data available*	NE†
Upstream Impacts of Activities	*Not estimated – no data available*	NE†
Consumption-Based Emissions	*Not estimated – no data available*	NE†
Total		*998,446*

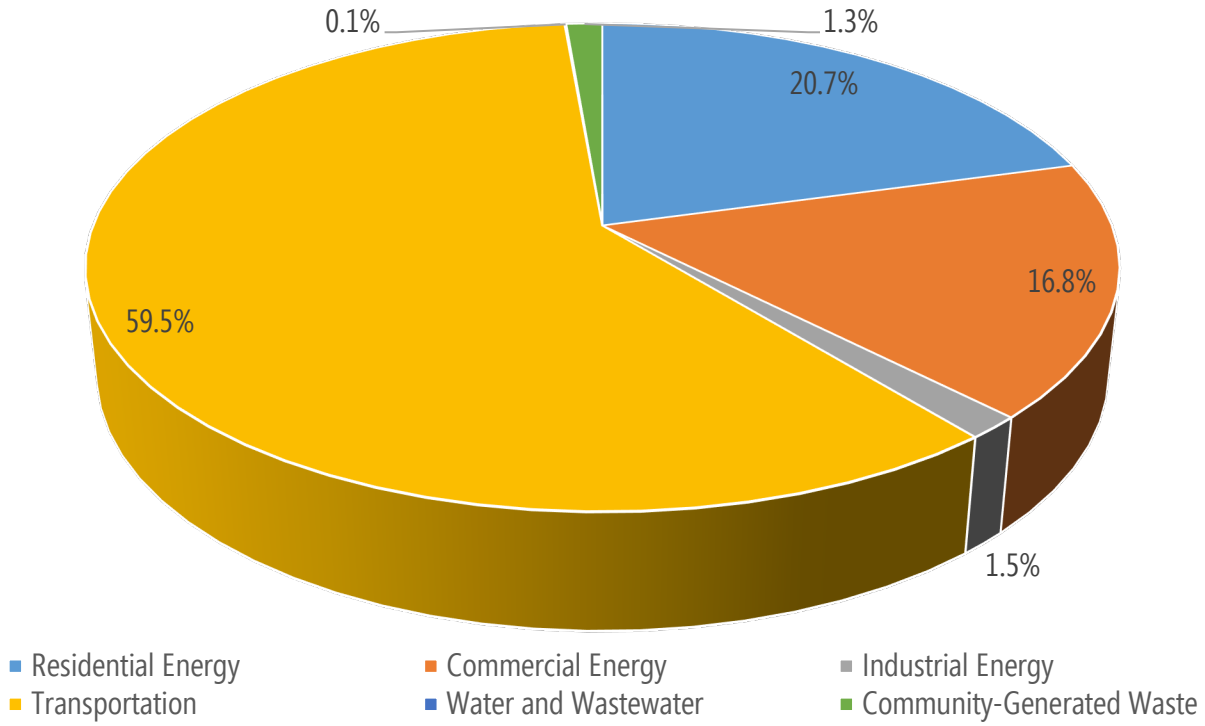
^Public Authority Electricity is a billing category established by FPL that distinguishes it from electricity sales to private residential, commercial, industrial and public street and highway lighting accounts. In Florida, this category typically refers to special purpose entities tasked with specific mandates; for example, water utility or transportation authorities. Due to limitations of the data obtained from FPL, it is not possible to disaggregate the individual authorities included in this category. This category is included in the Community totals.

†NE = Not Estimated. Emissions occur but have not been estimated or reported (e.g., data unavailable, effort required not justifiable).

‡NO = Not Occurring. The source or activity does not occur or exist within the community.

*Potable water treatment and methane emissions from waste water treatment are shown for informational purposes. Emissions from potable water treatment are accounted for in the Commercial / Industrial sector. Methane emissions are not included in totals to maintain consistency with the City of Boynton Beach's 2015 GHG inventory. Emissions are related to the South Central Regional Wastewater Treatment and Disposal Plant, which services Delray Beach and Boynton Beach.

FIGURE 3: COMMUNITY-WIDE EMISSIONS BY SECTOR, 2017



Community Inventory Data Sources and Methods

This section details data sources and methods used to complete the emissions estimates for each sector. Unless otherwise noted, data was collected and provided by Delray Beach staff.

Purchased Electricity

Emissions in the Residential, Commercial and Industrial sectors are related to purchased electricity (Scope 2 emissions). Total electric consumption totaled nearly 850 million kilowatt-hours in 2017, with the residential commercial and industrial sectors consuming 53%, 43% and 4%, respectively. Data to calculate electricity was provided by Florida Power and Light (FPL). Disaggregation of usage and emissions beyond the residential, commercial and industrial sectors (e.g. Hospitality / Tourism, an important industry in the Community) is not possible based on the data provided by FPL.

Purchased Fuels

Emissions in the Residential, Commercial and Industrial sectors also include combustion of fuels for heating or industrial processes. Florida City Gas was contacted for natural gas consumption data; however, it did not respond to requests for data. Propane is marketed by a variety of unregulated entities. Therefore, natural gas and propane emissions for the residential sector were estimated using Community Protocol method BE1.2. This method calculates an average energy use per household and applies it to the estimated number of households using these fuels in Delray Beach to calculate community energy use. It is based on statewide data from the Energy Information Agency (EIA) and the American Community Survey (ACS). These data sources indicate that only 4.5% and 1.0% of households use natural gas or propane for home heating, making them a relatively small source of emissions. Commercial and industrial natural gas and propane emissions could not be estimated using this method, and were not included in

the inventory. However, natural gas and propane represent only 8% and less than 1%, respectively, of total commercial energy use statewide. Industrial use of these fuels is also likely very small, given that industrial properties are only 4% of City land use and 4% of community electric sales. Therefore, while total community-wide natural gas and propane consumption is underestimated, they are not likely a major source of emissions.

Transportation

Transportation emissions estimates were developed using vehicle miles travelled (VMT) data within the city limits interpolated from the Southeast Florida Regional Planning Model (SERPM) Version 7. SERPM is a "bottom-up" forecasting tool that models individual travel choices with maximum behavioral realism, including both household-level and person-level travel choices. It is tailored to southeast Florida, and carefully validated and calibrated to replicate observed traffic counts and other monitoring data sources with the necessary level of accuracy. The smallest level of geographic aggregation in the model where model calculations are made is the Transportation Activity Zone (TAZ). TAZs are grouped to into study districts at the scale of a site, subarea, corridor or region. In this case, the study area corresponds with the geopolitical boundary of the City of Delray Beach. The model estimates daily VMT for both passenger and freight vehicles and all common fuel types by road functional class, including urban interstates, freeways, arterials, collectors and local roads in the City. Because SERPM is available for a base year (2010) and a future year (2040), linear interpolation was used to estimate VMT for the inventory year (2017). The traffic network for the City of Delray Beach was extracted from the larger network provided in SERPM.

The Motor Vehicle Emissions Simulator (MOVES) was utilized to estimate mobile source emissions rates. These rates were combined with the SERPM VMT data to calculate GHG emissions for each link within the City's road network. Emissions are estimated based on a typical weekday in June 2017. Transportation emissions are estimated this way since they are influenced by temperature. Average daily high and low temperatures in June are slightly warmer than annual averages for Delray Beach. Using this month provides a conservative estimate of annual emissions.

Transportation emissions are the Community's main contribution to global greenhouse gas pollution. They are dominated by internal combustion engines consuming gasoline and diesel fuels. In Delray Beach, most emissions occur on arterial (44%) and interstate road classes (33%). Major arterials in Delray Beach include US 1 / Federal Highway, State Road 806 / Atlantic Avenue, Linton Boulevard, and Florida A1A / Ocean Boulevard, which connect the City to the greater South Florida region. Interstate 95, the primary North-South interstate on the east coast, passes through the City, greatly contributing emissions in a manner not easily influenced by the community.

The emergence of alternative fuels, including electric vehicles, while currently making up about 1% of total transportation energy use, provide opportunities to reduce emissions, as do efforts to shift trips to alternative modes, such as transit, bicycling and walking.

Water / Wastewater

Water Treatment

The City of Delray Beach's water is treated at the Central Water Treatment Plant located at 200 SW 6th Street, Delray Beach. This facility does not report its GHG emissions. To estimate emissions, RS&H requested activity data. The City provided electricity consumption at the facility. The City did not provide natural gas consumption totals, indicating natural gas is not used at the facility. As a result, water

treatment emissions are estimated only for electricity use at the facility. This value (1,730 $mtCO_2e$) is shown in Table 1 above for informational purposes, since the City of Delray Beach operates this facility. The emissions are accounted for as part of the electricity use in the Industrial sector.

Wastewater Treatment

The South Central Regional Wastewater Treatment and Disposal Plant (SCRWWTP) services the cities of Delray Beach and Boynton Beach. Plant operations are controlled by an Independent Special District with a board comprised of the Commissions of both cities. The plant is located on Congress Avenue in Delray Beach.

Emissions for SCRWWTP totaling 653 $mtCO_2e$ were estimated in three categories: process-based nitrous oxide (N_20) emissions, effluent-based N_20 emissions and methane (CH_4) emissions. Emissions from electric use are included in the Purchased Electricity category described above. Both N_20 and CH_4 have higher global warming potential (GWP) than CO_2 (265x and 28x, respectively). Thus, relatively small emissions have significant climate impacts.

Population-based calculations were used to estimate wastewater treatment N_2O emissions for Delray Beach in 2017. Population estimates were obtained from the US Census. The small number of persons served by septic systems was deducted from the total population. (Emissions from septic systems were estimated separately, as described below). Community Protocol Equation WW.7 - N_2O Process Emission from WWTP was used to estimate N_2O process emissions, and the ICLEI calculator "Process N_2O from Effluent Discharge to Rivers and Estuaries" was used to estimate effluent emissions using population values.

Methane (CH_4) emissions from the SCRWWTP were estimated as an “Information-only” item, meaning they were not added to the community inventory total. This was done to maintain consistency with the 2015 Boynton Beach GHG Inventory Update, which did not include CH_4 emissions from the SCRWWTP facility. A population-based calculation of CH_4 emissions for wastewater treatment resulted in an estimate of 22,865 $mtCO_2e$, for Delray Beach’s contribution, using ICLEI Equation WW.6 - Alternate Methane Emissions from lagoons. Relevance of this CH_4 estimate to SCRWWTP operations should be validated in updates to this inventory.

The City indicated 20 or fewer households use septic systems within its jurisdiction. ICLEI equation WW.11 was used to estimate septic system emissions based on the population that utilizes them within the City. Emissions from this source amounted to 5.5 $mtCO_2e$ and are *de minimus*.

Agriculture

Since there are no widespread or significant agricultural land uses occurring in Delray Beach, this category was omitted from the inventory.

Solid Waste

Delray Beach waste is transported outside the community for incineration by the Solid Waste Authority of Palm Beach County (SWA). Based on conversations with SWA, materials are incinerated at both Renewable Energy Facility 1 (REF1) and REF2 facilities; however, it is not possible to track exactly how much waste is

processed at each facility. Since the operation of the two facilities is similar, the REF2 facility was used to model emissions.

At both facilities, waste is incinerated and recyclable metals are recovered from the ash. Energy produced by the plant is sold to local power utilities. The City provided the waste tonnage transported for disposal in 2017. ICLEI's ClearPath Combustion of Solid Waste calculator was used to develop the GHG emissions estimate based on the mass of waste Delray Beach contributed. Bulk materials and vegetative waste types were excluded from the analysis because they are recycled and biogenic, respectively. Recycled materials do not directly generate GHG emissions. Biogenic materials such as wood and vegetation contain embedded carbon that plants sequestered from the atmosphere as they grew. While emissions are released when they are combusted, they do not contribute a net increase in GHGs to the atmosphere. Note that incineration of biogenic material does results in emissions that affect ambient air quality, including oxides of nitrogen, carbon monoxide and particulate matter, that can be harmful to human health.

Process and Fugitive Emissions, Upstream Impacts of Activities and Consumption-Based Emissions

Due to a lack of available information, the categories Process and Fugitive Emissions, Upstream Impacts of Activities, and Consumption-Based Emissions have been excluded from the inventory. Process and fugitive emissions in this category include fugitive emission of Hydrofluorocarbons (HFCs) and Chlorofluorocarbons (CFCs); emissions from oil, coal and other mining processing, storage and transportation; and natural gas distribution. Fugitive emissions from HFCs and CFCs occur in the community; however, due to their dispersed nature, good data does not exist for estimating their contribution to the Delray Beach's total. Emissions from mining activities and natural gas distribution are likely non-existent or *de minimus*. For these reasons, emissions related to these activities are not estimated at this time.

Consumption-based GHG accounting is an alternative to the sector-based approach to measuring city GHG emissions used in this inventory. A consumption-based inventory includes the emissions impact of goods produced outside of the community but consumed there. In contrast, a sector-based inventory measures the emissions produced within the jurisdiction, even those used to produce goods which are consumed elsewhere. A consumption-based approach may not effectively inform decision-making, since high-quality activity data that allows differentiation between the benefits of various consumption choices is not typically available.[4] Further, consumption-based inventories typically result in higher overall emissions estimates, since they include sources not directly under the control of the local government. For these reasons, consumption-based emissions have not been included in the present inventory.

Urban Forestry

Delray Beach's tree canopy is among its distinguishing features, representing nearly 2,400 acres and providing a canopy for 23% of the City's area. It contributes greatly to the economic, social and environmental health of the community.

Current community and local government protocols for developing greenhouse gas inventories including those utilized to develop this GHG inventory explicitly exclude the impact of urban forestry on emissions.

[4] ICLEI: Perspectives on Community-scale GHG Accounting

This is because emissions mitigation from biological sequestration are uncertain, change over time and are difficult to accurately account. For these reasons, emissions sequestered by the tree canopy have not been directly included in the emissions inventory, despite the existence of tools such as i-Tree, developed by the US Forest Service to estimate the ecosystem services provide by trees. An estimate provided by the City sourced from this tool suggest that the urban forestry is sequestering 75,200 $mtCO_2e$.

Caution should be used with such estimates, since sequestration cannot be expected to be maintained indefinitely. Particularly in mature urban forests sequestration may be expected to plateau and decline over time, with no net benefit to the Community's GHG inventory. While urban forestry's impact on the Community's emissions is uncertain and complex, it is an issue worthy of further study as the City continues to inventory its emissions sources and sinks, and plans measures to mitigate its emissions. ICLEI's Urban Forestry Toolkit is a valuable resource for these tasks.

LOCAL GOVERNMENT OPERATIONS (LGO)

The local government operations inventory allows city operations to understand its own impact on the community's emissions and to effectively plan to reduce those emissions over which it has significant influence or direct control. It represents the total amount of greenhouse gas (GHG) emissions associated with local government operations for calendar year 2017.

Local Government Operations Inventory Overview

In 2017, LGO emissions from Delray Beach totaled **19,651 mtCO_2e**. Table 3 shows local government sectors, activities, and estimated emissions included in this total. Figure 2 shows the percentage of the total contributed by each sector.

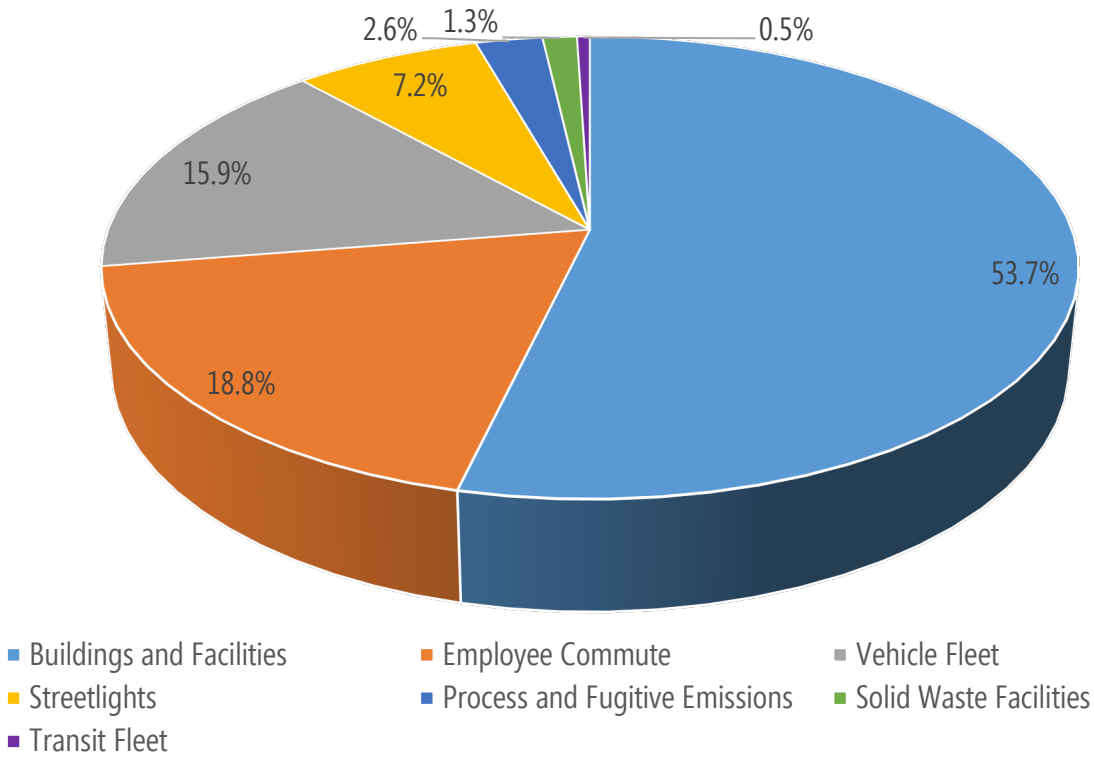
TABLE 2: 2013 LGO INVENTORY SECTORS, ACTIVITIES, AND EMISSIONS

Sector	Activities	Emissions ($mtCO_2e$)	Percent
Buildings / Facilities	Electricity consumption	9,896	50.4%
	Electric Power T&D losses	659	3.4%
	Stationary fuel combustion	NE†	-
Streetlights	Electricity consumption (Streetlights and other lighting accounts)	1,424	7.2%
Port / Airport Facilities	*Not occurring – there are no city-owned Port/Airport facilities*	NO‡	-
Vehicle Fleet	Fleet vehicle emissions	3,014	15.3%
	Off-highway vehicle emissions	103	0.5%
Transit Fleet	Transit Fleet vehicle emissions (Trolley)	98	0.5%
Employee Commute		3,687	18.8%
Solid Waste Facilities	Waste generation at city facilities	262	1.3%
Water and Wastewater Treatment Facilities	*See Community Inventory section.*	-	-
Power Generation	*Not estimated – there are no city-owned power generation facilities other than generators. No generator information was available.*	NO‡	-
Fugitive Emissions	Fugitive emissions related to HVAC systems	510	2.6%
Total		*19,651*	*100%*

†NE = Not Estimated. Emissions occur but have not been estimated or reported (e.g., data unavailable, effort required not justifiable).

‡NO = Not Occurring. The source or activity does not occur or exist within the community.

FIGURE 4: LOCAL GOVERNMENT OPERATIONS EMISSIONS, 2017



LGO Inventory Data Sources and Methods

This section details data sources, methods and sources used to complete the emissions estimates for each sector.

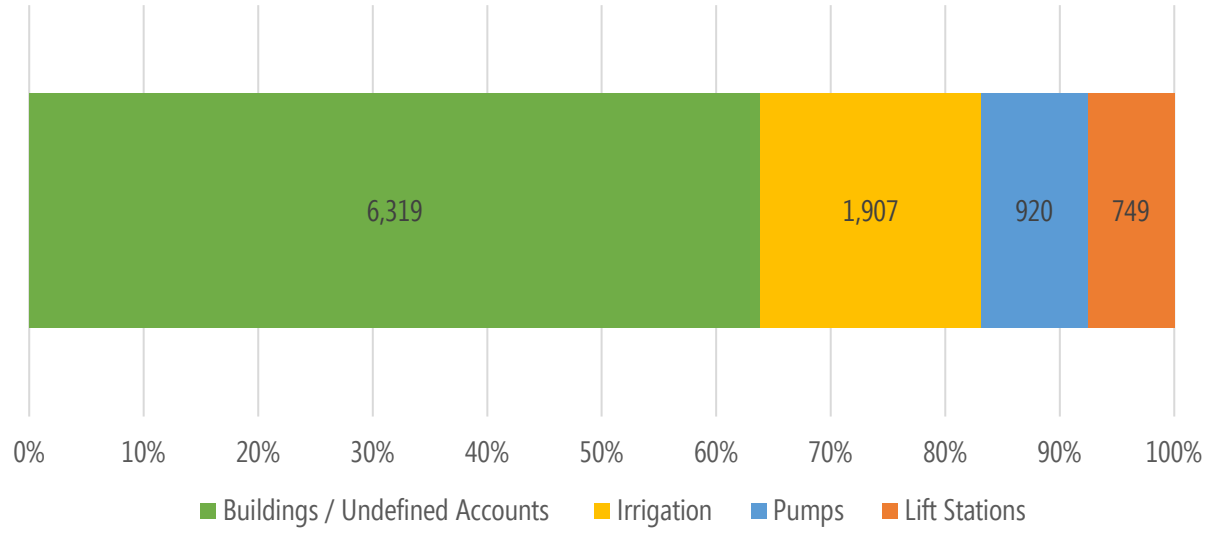
Building and Facilities

Buildings and Facilities generate GHG emissions through electricity consumption. Emissions also occur from electricity lost through inefficiencies in the utility's transmission and distribution system (T&D losses). T&D losses of 5.58% were assumed, using the 2016 EPA Emissions and Generation Resource Integrated Database (EGRID) estimate for the eastern US. Emissions estimates were calculated based on the city's utility billing records, obtained from FPL. A third category of Building and Facilities emissions, Stationary Fuel Combustion, was not included in the inventory, because no data was available. Stationary Fuel Combustion includes use of fuels like natural gas and propane to heat buildings, domestic water or provide energy to other stationary processes. This inventory assumes use of these fuels is minimal within government operations.

Keyword searches were performed to extract street-lighting accounts, which are not included in the buildings and facilities category.

Keyword searches of FPL account identifiers were further used to preliminarily disaggregate Building and Facility emissions from electricity consumption (i.e. excluding T&D and streetlighting) into Irrigation, Pumps and Lift Station end-uses. A final category is comprised of Buildings and other FPL accounts that could not be definitively characterized. Emissions from these preliminary groups are shown below (Figure 3). By definitively associating FPL accounts with meaningful categories (e.g. departments, utilities, buildings, facilities, etc.), the City can increase the resolution of its emissions data. Greater resolution will help plan and prioritize emissions reduction activities.

FIGURE 5: LGO BUILDINGS AND FACILITIES EMISSIONS BY PRELIMINARY END-USE CATEGORIES ($MTCO_2E$)



Streetlights

City owned or operated streetlights contribute to emissions through electricity consumption. Emissions for streetlights and other City lighting accounts were calculated based on the city's utility billing data. These accounts were identified through keyword searches.

Vehicle Fleet and Transit Fleet

The City operates fleets of on-road vehicles, including those supporting its transit system. It also operates a fleet of off-road vehicles. These vehicles contribute to emissions through use of gasoline or diesel fuel. Vehicle Fleet and Transit Fleet (i.e. the city's Trolley service) emissions were calculated based on fuel purchase records supplied by the City's Fleet Maintenance division. Emissions from contracted work, such as road or sewer projects using vehicles owned by third-parties are not included in the emissions inventory. They are considered Scope 3 emissions not directly under the City's operational control. However, they may be an important source of emissions that the City could elect to track, quantify and influence in the future. Tools such as the Envision rating system provide criteria for incorporating sustainable approaches into planning, design, construction and operation of infrastructure projects.

Employee Commute

Employee Commute related emissions are the second largest category of emission (19%). Emissions were estimated using GIS analysis. The analysis calculates the distance between a central point within the

residential zip code of each of the City's 1,324 employees and the 33444 zip code that contains City Hall and Public Works offices. A high-limit distance of 120 miles was used to exclude suspect values. Assumptions regarding the share of full- and part-time workers, working days per year and average fuel economy were utilized to estimate fuel consumption of 399,675 gallons of gasoline per year. This method results in an average one-way commuting distance of about 33 miles. Estimates of employee commute should be refined in future GHG inventory updates by conducting an employee commute survey that elicits higher quality data on commute distance, frequency and vehicle technology.

Solid Waste Facilities

Delray Beach municipal solid waste is transported to the Solid Waste Authority of Palm Beach County's REF1 and REF2 waste to energy incinerator plants. Recyclable metals are removed from the waste after incineration. Energy produced by the plant is sold to local utilities.

The City does not currently track the volume or mass of waste generated (or recycled) by City facilities. Instead the City reported the quantity of bins, their size and frequency of pick up. To calculate waste and recycling tonnages, a conversion factor of 150 pounds of waste per cubic yard of container space was applied following EPA guidance (the middle of the accepted range)[5].

Because there is concern that up to 50% collected recyclables are incinerated, 50% of estimated recycling totals were added to the waste generation totals. In future tracking, the exact volumes or tonnages disposed / recycled would allow a more accurate emissions calculation and support waste minimization efforts.

Water and Wastewater Treatment Facilities

Water Treatment

Emissions associated with electricity use at the City's Central Water Treatment Plant (CWTP), located at 200 SW 6th Street amounted to 1,730 $mtCO_2e$ in 2017. These emissions are included in the Buildings and Facilities sector of the LGO inventory. They are also included for information purposes in the Community inventory Water/Wastewater sector and accounted for in the Industrial energy use sector.

Wastewater Treatment

The South Central Regional Wastewater Treatment and Disposal Plant services the cities of Delray Beach and Boynton Beach. Plant operations are controlled by an Independent Special District with a board comprised of the Commissions of both cities. Process and effluent emissions associated with the SCRWWTP facility, and scope 2 emissions from its electricity usage are included in the community-wide inventory. They were estimated based on the population of Delray Beach and do not include the portion of the SCRWWTP's emissions attributable to Boynton Beach.

Utility-scale Power Generation

The City does not own or operate utility-scale power plants or any other significant power generation sources. Data on fuel use by stationary generators was not available. While this information would help refine the inventory, generators are typically used only when tested and in emergencies or power outages. As a result, generator emissions are likely *de minimus* relative to the inventory total (i.e., less than 2%).

[5] US-EPA "Standard Volume-to-weight Conversion factors", accessed 3/9/15 at http://www.epa.gov/osw/conserve/tools/recmeas/docs/guide_b.pdf

Fugitive Emissions

Pressurized chemicals such as the refrigerants used in heating, ventilation and air conditioning (HVAC) systems leak or are released via maintenance activities. These substances are very potent greenhouse gases, so small releases have a significant effect. Emissions can be reduced by replacing the strongest greenhouse gases with less potent alternatives, as well as enhanced maintenance processes. No direct data on HVAC system capacity, leakage or recharge was available. Emissions were estimated using the World Resource Institute screening method. The City supplied lists of facilities and square footages that were used to develop the estimate. This approach results in a conservative estimate.

GHG EMISSIONS FORECAST

Forecast Methodology

While establishing an emissions baseline lays the groundwork for measuring and reporting emissions, it is also useful to forecast emissions over time to see how projected rates of population growth and energy consumption would affect emissions under a business-as-usual (BAU) scenario. A BAU scenario assumes that no further actions are taken to reduce emissions within the City.

RS&H prepared a community-wide BAU forecast over an 18-year time horizon from 2017 through 2035. Data to support forecasting beyond 2035 was not available. The community-wide forecast encompasses local government operations emissions, which are part of the community's emissions. LGO emissions were not forecasted since growth in operational emissions are not closely correlated to economy-wide indicators of growth (e.g. population, energy demand, etc.).

A review of GHG emissions forecasts performed by ICLEI members revealed a wide range of methods and growth rate indicators. In the interest of simplicity and reproducibility, three sources for growth rate indicators were used to develop the city's BAU forecast. City of Delray Beach Population growth projections from the Palm Beach County Population Allocation Model were used to estimate population growth through 2035.[6] For categories related to energy use (e.g. transportation and facilities energy consumption) the U.S. Energy Information Agency (EIA) Annual Energy Outlook 2018 total energy projection for the southeast region was used.[7] For water and wastewater demand, the South Florida Water Management District (SFWMD) Lower East Coast Water Supply Plan projection for increase in water demand was used.[8]

Uncertainty is inherent in any attempt to forecast the future. A wide variety of factors may influence future emissions, including macroeconomic variation, emerging technologies, and other, unforeseen factors. The forecast does not include local growth indicators such as building construction or planned development, since these factors interact with regional or national trends. For example, despite economic growth, nationwide GHG emissions have declined over the past ten years. The BAU forecast should be regarded as a planning tool. For instance, using this GHG inventory as a basis, City planners could evaluate estimated contributions of new development to the GHG emissions as part of policies that encourage sustainable design, construction and operations of buildings and infrastructure.

Community Inventory Forecast Results

The Community GHG Emissions forecast indicates growth in the transportation, residential, and commercial sectors will result in GHG emissions gradually increasing to 1,158,736 $mtCO_2e$ by 2035 (Figure 4). This represents an annual average increase of about 0.8%. Increases in industrial energy use, solid waste, and

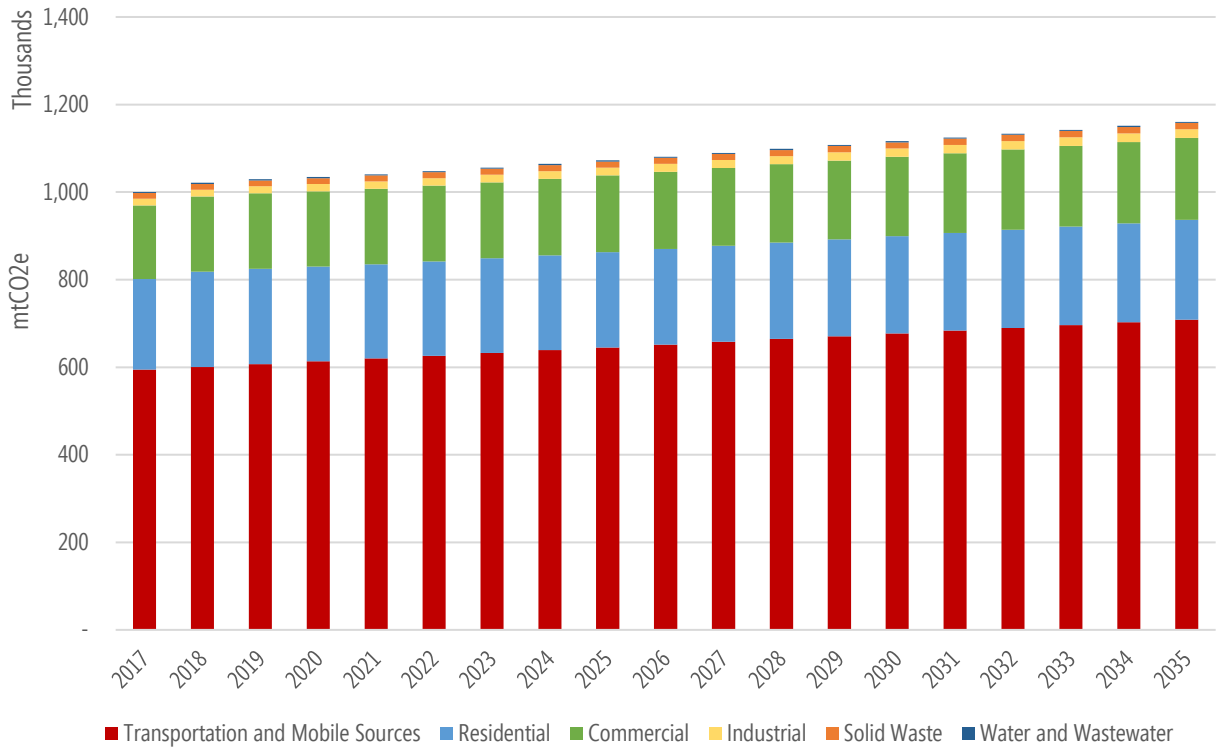
[6] "Palm Beach County 2015 Population Allocation Model", accessed November 26, 2018 at http://discover.pbcgov.org/pzb/planning/NewsReleases/Population-Allocation-Model.aspx

[7] "Energy Consumption by Sector and Source, South Atlantic, Reference case", accessed November 26, 2018 at http://www.eia.gov/forecasts/aeo/supplement/suptab_5.xlsx

[8] "SFWMD 2013 Lower East Coast Water Supply Plan", accessed November 26, 2018 at https://www.sfwmd.gov/sites/default/files/documents/2013_lec_plan.pdf

water/wastewater treatment related emissions are less significant, since they make up a smaller proportion of the inventory total.

FIGURE 6: CITY OF DELRAY BEACH COMMUNITY EMISSIONS FORECAST, 2017 – 2035



CLIMATE ACTION RECOMMENDATIONS

EMISSIONS REDUCTION TARGETS

Preliminary recommended emission reductions targets are shown in Table 3. These recommendations represent a first step in the process of setting SMART goals for climate action.[9] These recommendations are informed by the City's first-ever GHG inventory and forecast, a survey of peer South Florida local governments, international political agreements and current climate science. The City should analyze the feasibility of a portfolio of specific emissions reductions strategies to calibrate and finalize these preliminary recommendations.

TABLE 3: RECOMMENDED EMISSIONS REDUCTION TARGETS

Goal	Target					Sector
Interim	20%	below	2017	by	2028	LGO
Mid Term	40%	below	2017	by	2035	LGO & Community
Long Term	80%	below	2017	by	2050	LGO & Community

South Florida governments have taken a variety of approaches to setting GHG emissions reduction targets. Targets typically consist of three parts: a percent reduction, a baseline year and a target year. Targets have been set for the community and / or government operations. Interim and / or long term targets have be set. Table 4 includes several targets set by peer governments in South Florida.

TABLE 4: SELECTED GHG EMISSIONS REDUCTION TARGETS SET BY SOUTH FLORIDA GOVERNMENTS

City / County	Target					Sector
Boynton Beach	18%	below	2006	by	2035	LGO
Coral Gables	20%	Below	2013	by	2035	LGO
Fort Lauderdale	20%	below	2010	by	2010	LGO
Miami	25%	below	2007	by	2015	LGO
Sunrise	7%	below	2016	by	2030	LGO
Sunrise	43%	below	2016	by	2060	LGO
Broward County	80%	below	2007	by	2050	Community
Miami	25%	below	2006	by	2020	Community
Miami-Dade County	20%	below	2008	by	2020	Community
Miami-Dade County	80%	below	2008	by	2050	Community
West Palm Beach	25%	below	2013	by	2025	Community
West Palm Beach	Net-zero			by	2050	Community

[9] SMART goals are Specific, Measurable, Achievable, Relevant and Time-bound.

In 2010, the United Nations Framework Convention on Climate Change (UNFCCC) agreed that future global warming should be limited below 2°C relative to pre-industrial levels based on current scientific consensus.[10] This equates to an emissions reduction of about 80% to 90% below 1990 levels by 2050 for industrialized areas.

The UNFCCC has influenced many local government GHG reduction targets, with many adopting an 80% reduction and the 2050 target year (e.g. Broward and Miami-Dade County). Most local governments have found establishing a 1990 baseline year infeasible due to lack of data. Instead they have established base years as practical.[11] Setting a LGO and community-wide goal to reduce emissions by 80% relative to 2017 emissions by 2050 would be consistent with climate science, as well as peer local governments.

This is an ambitious goal, implying average annual emission reductions of about 5% for local government operations and the community. To manage the challenge of achieving long term GHG emissions reductions goals, many local governments have adopted interim goals (e.g. West Palm Beach, Sunrise, Miami-Dade County, Miami).

Good interim goals are challenging, but achievable. They are also relevant to existing management frameworks, as they better correlate to capital improvement planning, comprehensive planning and strategic goals. Setting a short-term goal to reduce emissions by 20% relative to 2017 by 2028 would require LGO annual emissions reduction of about 2% over a ten-year period. US emissions have decreased by about 1% annually over the last ten years. Assuming this "economy-wide" trend continues, this goal would imply that Delray Beach take additional, proactive efforts to reduce emissions. Since the local government only has control over its own operations, it is appropriate for this interim goal to extend only to this sector.

A mid-term goal could be also considered for the year 2035, giving the City eighteen years to meet the goal. A 40% reduction by 2035 would require annual reductions of about 2.7%. This is a challenging goal requiring an increasing pace of emissions reductions in future years to reach a goal consistent with the international targets.

Within local government operations, buildings / facilities and the vehicle fleet are the most promising sectors for emissions reductions. Renewable energy and energy efficiency projects can reduce emissions in the former category. Prioritizing fuel economy and utilizing alternative fuels are effective fleet emissions reduction strategies.

As Florida's electric power sources continue to de-carbonize, community energy efficiency projects will remain very important. Community transportation poses the greatest challenge. Smart growth planning techniques and promotion of alternative transportation modes and fuels are areas where the City can influence the Community's transportation emissions trends.

[10] The 2°C global temperature target represents the current scientific consensus for prevention of dangerous anthropogenic interference with the climate. However, the global temperature increase associated with an unacceptable global temperature increase has not been scientifically affirmed. The Paris Agreement proposed to keep the increase in global temperature to below 2.0°C and pursue efforts to limit it to 1.5°C above pre-industrial levels.

[11] US emissions have increased by about 2.5% since 1990. As a result, this approach remains meaningful relative to the objective of limiting warming to 2°C.

CLIMATE DATA MANAGEMENT

The scope and complexity of LGO and community emissions sources requires a robust set of metrics to monitor trends and support continual improvement of emission reduction actions.

The City's existing data management capacity has enabled assembly of a broad array of information that makes its first-ever GHG inventory possible. Improvements to the City's data management scope and systems will support the next phases of greenhouse gas management.

Based on the data collection and analysis process used to establish this inventory, several metrics and analyses should be incorporated into the City's management processes to better understand and control greenhouse gas emissions.

- Definitively associate utility billing accounts with operationally meaningful categories, such as processes, buildings, facilities, utilities, departments, etc.
- Establish a framework for reporting on LGO emissions in an operationally meaningful manner (e.g. by department, service, etc.,)
- Install submeters at locations with multiple electricity end uses.
- Submeter major process-related energy end uses, such as data centers or water utilities.
- Track fugitive emissions from stationary and mobile HVAC systems, including establishing a database of system specifications and maintenance records.
- Track fuel use from use of stationary generators.
- Track municipal solid waste and recycling by volume or mass.
- Complete an employee commuting survey to improve the quality of estimates of emissions from employee commuting and gather information that could be used to influence travel choices.
- Establish a protocol for long-term tracking and reporting on GHG sequestration from the City's tree canopy.

In addition to these recommendations, an integrated database solution should be considered to automate collection, normalize metrics, and regularly report on progress. Such a system will allow managers to evaluate past and on-going efforts and plan new initiatives necessary to reach City goals. Such systems may cost between $50,000 and $100,000 to license and configure or develop, with $2,000 to $10,000 required annually to maintain and upgrade software and functionality over time.

ENERGY AND WASTE ASSESSMENTS

Energy use in buildings and facilities constitutes the majority of LGO emissions (66%). It can be significantly reduced by identifying, designing and constructing cost-effective energy efficiency and conservation measures. Measures can be identified by evaluating major building systems (HVAC, lighting, building automation, water heating, building envelope and special processes) through design reviews, energy audits and/or commissioning (Cx).

- Design reviews can be applied to plans for new construction, ensuring that the latest energy efficiency techniques are included.

- Energy audits systematically investigate an existing facility's energy end-uses, developing cost-benefit analyses for retrofits that save energy.
- Appropriate for larger, more complex buildings with interactive systems and sophisticated controls, Commissioning redresses facility problems that develop over time as equipment ages and usage patterns change. Often it resolves problems that have persisted since design or construction. Examples include equipment or lighting that is on when it may not need to be; systems that do not adequately dehumidify, cool too much or simultaneously heat and cool when they should not; setpoints, sensors and thermostats that are out of calibration; air balancing systems that are not optimal; controls sequences that are functioning incorrectly, etc. Many operations and control improvements cost little or nothing to implement, making Cx particularly cost effective.

Energy audits and commissioning services average between $0.20 to $0.60 per square foot, with lower or higher costs possible based on the size of facilities and the complexity of energy end-uses. Typically, larger or less complex buildings are less expensive to evaluate than smaller or more complex facilities. Best practice for energy audits and commissioning suggests repeating assessments on a five-year cycle to account for advance in building technologies, deterioration of equipment and changes in operating parameters.

A waste audit, also known as a waste characterization study, identifies and quantifies the various materials in an organization's waste stream and reveals common waste practices. Characterizing waste uncovers opportunities to improve waste diversion rates, increase recycling, reduce contamination of recycling streams, reduce greenhouse gas emissions, and lower disposal costs. The information derived from a waste audit can inform materials minimization program design and influence negotiations with waste haulers / recyclers. A waste audit report prepared for Palo Alto in 2012 found that 70% of the city's waste stream could potentially be diverted through either recycling or composting. Performing a waste audit is an essential first step to identifying markets for recyclables and realizing cost avoidance associated with waste diversion. A waste audit typically costs less than $50,000 depending on the number of evaluations required to accurately characterize the waste stream.

SUSTAINABILITY / CLIMATE ACTION PLAN

As noted above, SMART goals for climate action should be consistent with a comprehensive program for reducing emissions. A climate action plan establishes a City-wide vision for greenhouse gas reduction and management, develops projects to achieve goals and provides a framework for implementing projects. A sustainability plan broadens these objectives to include additional environmental goals (e.g. water and air quality), as well as quality of life and economic development aims.

A sustainability / climate action plan typically proceeds in three phases.

- The first phase entails comprehensive data gathering and gap analysis, baseline assessment, benchmarking and analysis. This phase provides a means of measuring future progress, while uncovering new opportunities for advancing the City's goals and objectives. This phase is partially complete as result of the City's first GHG inventory.

- The second phase elicits and develops City staff's (and other stakeholders') ideas to set goals and establish projects to meet those goals, supplemented by quantitative cost-benefit analysis. This phase assembles a portfolio of initiatives designed to incrementally achieve the City's emission reductions goals over time.
- The final phase considers implementation of emissions reduction projects, firming up goals, budgets, schedules and responsibilities that are tied to existing City management frameworks (e.g. strategic, capital and comprehensive plans; resolutions and ordinances, etc.). It also identifies funding opportunities and a framework for monitoring and communicating results.

The cost of a sustainability / climate action plan varies substantially based on scope and complexity, ranging from about $70,000 to $200,000.

COMMUNITY VULNERABILITY ASSESSMENT

Stabilizing global temperatures at less than 2°C above pre-industrial levels is a challenge that requires a coordinated global effort. Even if the world's governments meet this goal, Delray Beach's climate will change as a result of warming already in progress from past and present emissions. The increasingly strong storms, rising seas, and warmer temperatures already experienced in South Florida as a result of 1°C of global warming will intensify and the City must be prepared to adapt to this new reality.

A Community Vulnerability Assessment will identify risks to City buildings, infrastructure, habitats and connections to vital services and resources such as storm shelters, transportation networks, schools, hospitals, landfills, utilities and groundwater. The assessment should be based on data-driven heat, storm, precipitation and flood elevation scenarios modeled on predicted future conditions.

It should also identify organizational risks to stakeholders, historically vulnerable areas, and vulnerable populations, helping the City understand how demographics may shift as a result of sea level rise and other climate related factors.

Risks should be analyzed and prioritized based on probability, cost, spatial extent and time horizon. Best practices from other coastal south Florida communities should be evaluated for applicability to the City. Potential adaptation and mitigation measures should be identified and screened via criteria including feasibility and cost, as well as social and environmental factors.

The resulting plan will help the City manage resources and prioritize investments to optimize operational continuity and minimize future risk. It will also help the City communicate risk and adaptation measures to the public.

The cost of such an assessment will vary from about $80,000 to $200,000 based on the level of detail required to inform the City's capital planning, comprehensive planning and strategic planning processes.

CONCLUSION

Delray Beach's first Greenhouse Gas (GHG) Inventory is an important step towards honoring its commitment to address climate change. It builds on a series of efforts to improve sustainability performance, reduce emissions that contribute to climate change and improve community resilience.

The inventory supports these efforts by quantifying the City's most significant contributions and establishing a baseline and forecast of emissions. It facilitates identification of opportunities to reduce emissions through policy, purchasing, operational efficiency and behavioral change and provides a basis for tracking and reporting on those efforts over time.

The inventory includes both community and local government operations perspectives.

From the Community perspective, the transportation sector is the largest single source of emissions (60%), with the residential and commercial energy use accounting for most of the balance of emissions (38%). Smart growth planning and regulatory initiatives that include promotion of alternative transportation modes and fuels and energy-efficient facility design, construction and operation present opportunities to influence these emissions.

From the perspective of local government operations, City-owned buildings and facilities contribute most to emissions (66%). The city's vehicle fleet operation and city streetlights are also important sources of emissions (20% and 9%, respectively). Renewable energy and energy efficiency projects can reduce energy use in facilities, including exterior lighting, while prioritizing fuel economy and utilizing alternative fuels can cut fleet emissions.

These patterns are comparable to peer South Florida municipalities.

The next step for the City is to establish emission reduction targets informed by this inventory, peer local governments, international efforts to combat climate change and current science. These goals should be supplemented by data management, energy and waste assessment, climate action planning and community vulnerability assessment initiatives.

Together, these recommendations constitute a holistic approach to managing and reducing community and local government operations GHG emissions, as well as the effects of climate change, in a cost-effective manner.

Following through with these recommendations will establish the City of Delray Beach's leadership locally and internationally as a community concerned with responding to the challenge posed by climate change. By meeting this challenge, Delray Beach can realize tangible, long-term benefits for the environment, economic development and quality of life of its citizens.