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CITY OF CHICAGO GREENHOUSE GAS INVENTORY REPORT

CALENDAR YEAR 2015

January 1 – December 31, 2015

Final Report

August 2017

Note on the differences between the ‘Draft 2015 Inventory’ released in January 2016 and the final inventory contained in this report:

In January 2017, the City of Chicago released a draft 2015 community greenhouse gas emissions inventory. While the values in the draft inventory were similar to the values in the final 2015 community inventory contained in this report, there are a few differences. The draft inventory had a total of 30,955,862 metric tons of carbon dioxide equivalent per year (MT CO₂e/year) emitted whereas the final inventory has a total of 32,651,379 MT CO₂e/year. The notable differences included increased electricity-related emissions and decreased on-road vehicle emissions. The reasons for these changes are as follows:

- **Electric Grid Emission Factor** – The draft 2015 inventory used a utility-specific emission factor for grid electricity. In the spring of 2017, the City completed an update of the 2005 and 2010 inventories. To make the 2005, 2010, and 2015 inventories directly comparable with each other, the City needed an emission factor from a consistent source that could be used for each reporting year. Due to changes in utility structure between 2005 and 2010, the City needed to switch the draft 2015 inventory electricity emission factor to the default U.S. EPA regional grid emission factor. This resulted in an increase in the reported level of scope 2 grid electricity emissions.
- **On-Road Vehicle Emissions** – In the interim between the development of the draft inventory and the final inventory, the Chicago Metropolitan Agency for Planning was able to provide the City with updated activity and emission factors to use to calculate on-road vehicle emissions in the community. These updated data resulted in a lower level of emissions compared to the value contained in the draft report.



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Acronyms and Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
CCAP	Chicago Climate Action Plan
CH ₄	methane
City	City of Chicago
CMAP	Chicago Metropolitan Agency for Planning
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
DSS	Department of Streets and Sanitation
GCoM	Global Covenant of Mayors for Climate and Energy
GDP	gross domestic product
GHG	greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories
GWP	global warming potential
HFCs	hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
k	thousand
kWh	kilowatt hour
LPG	liquefied petroleum gas
MOVES	U.S. EPA Motor Vehicle Emission Simulator
MT CO ₂ e	metric tonnes of carbon dioxide equivalent
N ₂ O	nitrous oxide
NF ₃	nitrogen trifluoride
NTD	National Transit Database
PFCs	perfluorocarbons
SF ₆	sulphur hexafluoride
SUVs	sports utility vehicles
tonnes	metric tons
U.S. EPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
WRP	Water Reclamation Plant

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EXECUTIVE SUMMARY

Summary of Results

The City of Chicago 2015 Community-scale Greenhouse Gas (GHG) Emissions Inventory results indicate community activities within the City of Chicago boundaries generated approximately 32,650,000 metric tonnes of carbon dioxide equivalent (MT CO₂e) in 2015.

This number reflects an 11 percent reduction in total emissions since the Chicago 2005 base year, an improvement in emissions intensity from approximately 13.0 MT CO₂e/capita¹ to 12.0 MT CO₂e/capita, and stronger improvements in economic efficiency, experiencing a change from approximately 7.6 MT CO₂e per \$100,000 (MT CO₂e/\$100k) of gross domestic product (GDP)² to 5.1 MT CO₂e/\$100k of GDP.

Background

The City of Chicago is a recognized leader in climate action planning. The City has assessed the economic, social and environmental risks of climate change and has begun implementing actions that will help minimize the effects on its community. The City has also begun taking aggressive action to reduce community GHG emissions and contribute to global climate protection efforts. In 2008, Mayor Richard M. Daley unveiled the Chicago Climate Action Plan (CCAP),³ which outlined the City's ambitious goals and actions to reduce community GHG emissions to 80 percent below 1990 levels by the year 2050, and established an interim goal of reducing emissions to 25% below 1990 levels by the year 2020. In June 2017, Mayor Rahm Emanuel expanded this leadership and committed the City of Chicago to the goal of reducing citywide greenhouse gas emissions to levels equivalent to or greater than 26-28% reduction from 2005 levels by 2025, which is the original commitment made by the Obama Administration as part of the United States' commitment to the Paris Climate Agreement.⁴ In addition, in April 2017, Mayor Emanuel announced the City will power all city public buildings with 100% renewable energy by 2025.⁵

To monitor progress towards these goals, the City has developed GHG emissions inventories for the years 1990, 2000, 2005 and 2010. Chicago joins other global cities in completing one of the first GPC-compliant GHG inventories in the world. The City of Chicago is a member of C40 Cities and joined the Global Covenant of Mayors for Climate and Energy (GCoM) in August

¹ City of Chicago population source: Census Bureau, United States Chamber of Commerce

² Regional GDP source: Bureau of Economic Analysis, United States Chamber of Commerce (values in 2015 dollars)

³ For more information, visit <http://www.chicagoclimateaction.org/>.

⁴ "Mayor Emanuel Signs Executive Order Committing Chicago to Guidelines of Paris Agreement." Press Release, Mayor Rahm Emanuel. June 7, 2017. <https://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2017/may/ParisAgreementExecOrder.html>

⁵ "Mayor Emanuel Announces City Buildings to be Powered by 100 Percent Renewable Energy by 2025." Press Release, Mayor Rahm Emanuel. April 9, 2017. <https://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2017/april/RenewableEnergy2025.html>

2015. The GCoM is the world's largest cooperative effort among mayors to reduce GHG emissions, track progress, and prepare for the impacts of climate change. As a signatory of the GCoM in 2015, the City of Chicago pledged to conduct a GHG emission inventory in compliance with the Global Protocol for Community-Scale GHG Emissions Inventories (GPC) in 2016.⁶ The GPC provides the first global standard protocol under which cities can complete community-scale inventories. Where previous community-scale inventories have been difficult to compare because of wide differences in methodologies, both across geography and time, often resulting in “apples-to-oranges” comparisons, the GPC provides a foundation upon which cities can conduct “apples-to-apples” comparisons of their own year-over-year GHG emissions going forward, as well as evaluate performance compared to other cities around the world.

The GPC-compliant 2015 Chicago Community GHG Emissions Inventory meets the GCoM requirement, and also provides the City with data to continue to monitor its progress toward achieving its 2020, 2025, and 2050 CCAP GHG emissions reduction goals. Additionally, the City has updated its 2005 and 2010 community inventories to be compliant with GPC guidelines. These updates allow direct, accurate comparisons of emissions between inventory years, and increase the City's ability to define effective emission reduction actions. As part of this effort, the City also attempted to revise its 1990 inventory, but the lack of available 1990 data prevented using the same methods that were used in the 2005, 2010, and 2015 inventories. Additionally, the methods used in the original 1990 inventory were determined to be insufficient for making accurate comparisons to the 2015 inventory and the updated 2005 and 2010 inventories.⁷

Given these inventory improvements and its commitment to the Paris Climate Agreement goals, the City will revise its emission target base year from 1990 to 2005, while maintaining the same ambitious level of emission reductions as defined in the original 1990-based target. This will allow increased accuracy in evaluating the community's emissions performance and its contribution to global climate protection efforts.

2015 Community GHG Emissions Inventory Results

In 2015, stationary energy emissions were the largest contributor to the community inventory, accounting for 72% (23,500,082 MT CO₂e) of total emissions. Transportation emissions contributed an additional 25% (8,048,463 MT CO₂e), with the waste sector responsible for the remaining 3% (1,102,834 MT CO₂e) of community emissions.

The four sub-sectors that together generated over 85% of Chicago's 2015 total GHG emissions included residential buildings (28%), commercial and institutional buildings and facilities (26%), on-road transportation (16%), and manufacturing industries and construction (17%).

Over half (51.5%) of Chicago's emissions are generated by fuel combustion within the city boundaries (Scope 1 emissions), followed by emissions from electricity consumption (Scope 2), which comprised approximately 45% of emissions. Remaining emissions (Scope 3) resulting from treatment and disposal of solid waste and wastewater generated within the city contributed less than 4% of the total 2015 GHG emissions.

⁶ For more information about the GPC, visit the [Greenhouse Gas Protocol for Cities website](#).

⁷ See description in Section 1.1 regarding the challenges in making the 1990 inventory comparable to the 2005, 2010, and 2015 inventories.

Over three-quarters of Scope 1 emissions were generated by just three sub-sectors: residential buildings (31%), on-road transportation (30%), and commercial and institutional buildings and facilities (16%). The majority of electricity-related emissions are generated in the Stationary Energy sector. More specifically, residential buildings (26%), commercial and institutional buildings and facilities (38%), and manufacturing industries and construction (33%) representing over 98% of the electricity consumed in Chicago in 2015.

Chicago's GHG Emission Trends

Conducting inventories at regular intervals allows a city to evaluate progress toward its emission reduction targets. To ensure comparability with the 2015 community inventory, the City updated the previously prepared 2005 and 2010 inventories. Once the updates were completed, the City was able to compare community emissions in the three years.

Key trends are shown below in Figure 1 and Tables 1 and 2 (on following page). By 2015, annual emissions were reduced by more than four million metric tons below 2005 levels. Between 2005 and 2010, community emissions decreased by 4.6% or by 0.9% per year. From 2005 to 2015, emissions decreased by 11.0% or by 1.1% per year.

Figure 1 – Community GHG Emissions 2005, 2010, 2015

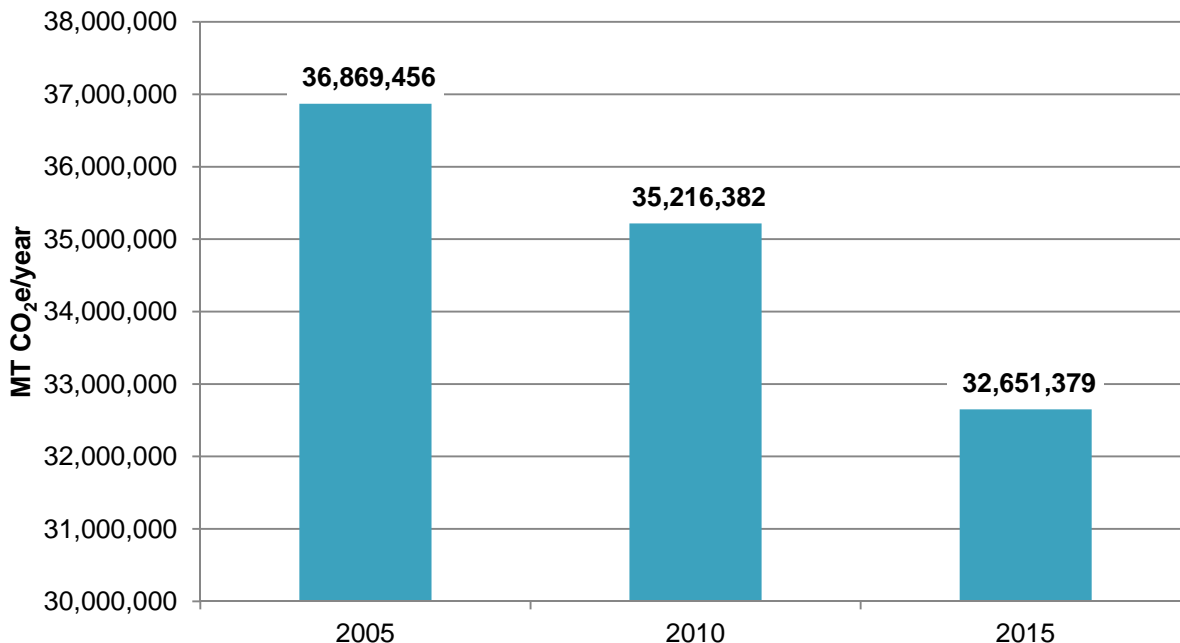


Table 1 – Community GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	36,700,027	35,021,969	32,651,379
Emissions Change from 2005 (MT CO ₂ e/year)	NA	-1,678,059	-4,048,648
% Change from 2005	NA	-4.6%	-11.0%
Emissions Intensity (MT CO ₂ e/capita)	12.91	12.99	12.00
Economic Emissions Efficiency (MT CO ₂ e/\$100k of GDP)	7.56	6.56	5.10

Table 2 – Sub-Sectors and Activity Types with the Largest (>100,000 MT CO₂e/year) Emission Reductions 2005 to 2015

Rank	GPC Sector #	Sub-Sector and Activity Type	Reduction in Emissions 2005 to 2015 (MT CO ₂ e/year)
1	I.2.1	Commercial and Manufacturing - Natural Gas	2,413,710
2	I.2.2	Commercial and Manufacturing - Electricity	1,495,033
3	I.1.2	Residential - Electricity	917,471
4	III.1.2	Solid Waste - Landfills	318,662
5	II.4.1	Aviation - Jet Kerosene	184,732
6	II.1.1	On-Road Transportation - Gasoline and Diesel	130,452
7	III.4.1 & 2	Wastewater Treatment and Discharge	98,585

Other key trends observed from the three inventories include:

1. The community achieved a modest improvement in emissions intensity from approximately 13.0 MT CO₂e/capita in 2005 to 12.0 MT CO₂e/capita in 2015.
2. During the same period, the community achieved stronger improvements in economic efficiency, experiencing a change from approximately 7.6 MT CO₂e/\$100k of gross domestic product (GDP) to 5.1 MT CO₂e/\$100k of GDP. Between 2005 and 2015, considerable reductions (3.9 million MT CO₂e/year) occurred in natural gas and electricity emissions in the commercial (I.2) and manufacturing (I.3) sectors.⁸
3. Between 2005 and 2015, residential electricity emissions decreased by approximately 900,000 MT CO₂e/year.
4. Electricity emissions per kilowatt hour (lbs CO₂e/kWh) decreased by 2.2% from 2005 to 2010 and by 10.2% between 2005 and 2015.

The only large increase in emissions occurred in residential natural gas consumption. Natural gas emissions increased by approximately 1.3 million MT CO₂e between 2005 and 2015. Additional information about the emission trends and the specific changes that occurred within each sector and sub-sector are described in the 'Emission Trends' section this report.

⁸ Due to aggregation of commercial and industrial natural gas and electricity utility data in 2005, it is unknown what portion of the reduction is attributable to the commercial (I.2) or manufacturing (I.3) sectors.

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1 INTRODUCTION

The City of Chicago is recognized as a global leader in assessing, evaluating and implementing actions to address and mitigate the economic, social and environmental risks and impacts of climate change faced by cities. Cities contribute significantly to the generation of greenhouse gas (GHG) emissions, generating more than 70% of the global energy-related carbon dioxide emissions.⁹ The concentration of human activity in cities represents great opportunity for cities to coordinate focused efforts to reduce GHG emissions while improving the quality of life for their citizens.

The City of Chicago has proactively pursued an aggressive GHG reduction agenda to positively influence the global impacts of climate change. In 2008, Mayor Richard M. Daley unveiled the Chicago Climate Action Plan (CCAP) which outlined the City's ambitious goals and actions to reduce Chicago's GHG emissions 80% below 1990 levels by the year 2050, with an interim goal for the year 2020 of 25% below 1990 levels. In June 2017, Mayor Rahm Emanuel committed the City of Chicago to the goal of reducing citywide greenhouse gas emissions to levels equivalent to or greater than 26-28% reduction from 2005 levels by the year 2025, which is the original commitment made by the Obama Administration as part of the United States' commitment to the Paris Accord.¹⁰ In addition, in April 2017, Mayor Emanuel announced the City will power all city public buildings with 100% renewable energy by 2025.¹¹ The City identified five categories for action to achieve these GHG reduction targets, including buildings, clean and renewable energy sources, transportation, waste and industrial pollution, and adaptation.

To set the CCAP GHG reduction goals and monitor progress towards those goals over time, the City has been evaluating its GHG emissions through inventories conducted for the years 1990, 2000, 2005, and 2010. In addition, the City of Chicago is a member of C40 Cities and joined the Global Covenant of Mayors for Climate and Energy (GCoM) in August 2015. The GCoM is the world's largest cooperative effort among mayors to reduce GHG emissions, track progress and prepare for the impacts of climate change. As a signatory of the GCoM in 2015, the City of Chicago pledged to conduct a GHG emission inventory in 2016. This 2015 GHG Inventory satisfies the Covenant requirement, and also provides the City with data to continue to monitor its progress toward achieving its 2020, 2025, and 2050 GHG reduction goals.

Over the past decade, Chicago has implemented a diverse suite of programs to work towards achieving energy and greenhouse gas emission reductions in the CCAP target strategies with initiatives in areas such as renewable energy, building retrofits and energy codes, energy benchmarking, smart meters, lighting upgrades, green roofs, bike sharing, bike and pedestrian-friendly streets, public transit efficiency and ridership, waste and water consumption, recycling,

⁹ "Why Cities?" C40. http://www.c40.org/why_cities, accessed June 22, 2017.

¹⁰ "Mayor Emanuel Signs Executive Order Committing Chicago to Guidelines of Paris Agreement." Press Release, Mayor Rahm Emanuel. June 7, 2017.
<https://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2017/may/ParisAgreementExecOrder.html>

¹¹ "Mayor Emanuel Announces City Buildings to be Powered by 100 Percent Renewable Energy by 2025." Press Release, Mayor Rahm Emanuel. April 9, 2017.
<https://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2017/april/RenewableEnergy2025.html>

and green infrastructure. These efforts are outlined and documented in both the Chicago Climate Action Plan¹² and Sustainable Chicago 2015¹³ program reports.

1.1 Revisions to Previous Inventories

The 2008 CCAP used an estimate of 1990 community emissions as its base year reference level for the City's emissions reduction targets. At the time of the plan's release, many progressive cities used 1990 emissions (the base year used in the Kyoto Protocol) as their target reference level. Due to the lack of activity data for 1990, some sectors in the inventory were developed using a practice called back-casting where activity levels in a past year are estimated by scaling measured activity levels from a future year backwards using a comparable scaling metric (e.g., population, jobs). While this can be an appropriate method to obtain a rough estimate of emissions levels in a year without measured data, the accuracy of such estimates is limited.

The City prepared the 2015 emission inventory to be compatible with the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC) and additional guidance from the GCoM. At that time, the City also made revisions to the 2005 and 2010 inventories to ensure direct comparability with the 2015 inventory and increase the City's ability to define effective emission reduction actions. As part of this effort, the City also attempted to revise the 1990 inventory, but the lack of available 1990 data prevented using the same methods that were used in the 2005, 2010, and 2015 inventories. Additionally, the back-casting methods used in the original 1990 inventory were determined to be insufficient for making accurate comparisons to the 2015 inventory and the updated 2005 and 2010 inventories.

Given these inventory improvements and its commitment to the Paris Climate Agreement goals, the City will revise its emission target base year from 1990 to 2005, while maintaining the same ambitious level of emission reductions as defined in the original 1990-based target. This transition is compatible with the change in international emissions reduction targets, which switched from 1990 (under the Kyoto Protocol) to 2005 or similar (under the Paris Agreement). This change will also allow increased accuracy in evaluating the community's emissions performance and its contribution to global climate protection efforts.

1.2 Components of Report

This report is presented in four sections, beginning with an introduction to the emissions inventory process and its purposes. The next section describes the results and analysis of the inventory, including specific descriptions of the emissions sectors and sub-sectors that were analyzed. The report then includes a comparison analysis of the City's emissions trends over time since 2005. The final section presents a summary of recommended actions for future inventory updates.

¹² The Climate Action Plan and related information can be found online at www.chicagoclimataction.org.

¹³ Sustainable Chicago 2015 can be found online at https://www.cityofchicago.org/city/en/progs/env/sustainable_chicago2015.html.

1.3 Greenhouse Gases and Climate Change

Gases in the atmosphere that trap heat radiated from the Earth's surface are called greenhouse gases (GHGs). GHGs can be either naturally occurring or emitted due to human activities. The main GHGs are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases.

- Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement) and land use changes. Carbon dioxide is removed from the atmosphere (or “sequestered”) when it is absorbed by plants as part of the biological carbon cycle.
- Methane is emitted during the production and transport of energy sources such as coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in solid waste landfills.
- Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.
- Fluorinated gases are manmade, powerful greenhouse gases that are emitted from a variety of industrial processes.

Each gas's effect on climate change depends on three main factors: the quantity of each gas in the atmosphere, how long they stay in the atmosphere, and how strongly they impact global temperatures. As the concentration of GHGs in the atmosphere increases beyond natural fluctuations largely as a result of human activities, particularly from the burning of fossil fuels, the global climate system shifts in ways that can have significant adverse impacts on environmental, economic, and social systems alike.

In Chicago, anticipated climate change risks include increasing numbers of extreme heat days in the summer and warmer winters, migrating seasons, and increasing numbers of intense, heavy rain storms as well as periods of drought, resulting in growing flood risks, stresses on the public health system and threats to the city's economy. For more information about how climate change will impact the Chicago region, visit the Chicago Climate Action website www.chicagoclimateaction.org.

1.4 Overview of the GHG Emissions Inventory

1.4.1 The Emissions Inventory

The City of Chicago has developed a community-scale GHG emissions inventory for calendar year 2015. A community-scale inventory represents estimated total GHG emissions from activities occurring within the city's geographical boundaries from all sectors of a city's economy, including residential, commercial, industrial, municipal, transportation, power, manufacturing and agricultural sectors. This section provides background information about the purpose and process of GHG emissions inventories.

1.4.2 Purpose of Emissions Inventories

A GHG emissions inventory is an estimate of GHGs emitted to, or removed from, the atmosphere over a specific period (usually one year). Preparation of an emissions inventory provides the City with an understanding of where Chicago's GHG emissions are coming from and serves as a starting point for developing and monitoring results of strategies that can effectively reduce GHG emissions. The City has previously developed community-scale GHG emissions inventories for the calendar years 1990, 2000, 2005, and 2010. The inventory presented within this report updates the community inventory for the 2015 calendar year and discusses trends between the inventory years to show progress over time.

An emissions inventory can help with any or all of the following tasks:

- Identifying the greatest sources of GHG emissions within a particular geographic region, department, or activity;
- Understanding emission trends over time;
- Quantifying the benefits of activities that reduce emissions;
- Establishing a basis for developing or updating an action plan;
- Tracking progress in reducing emissions; and
- Setting and/or revisiting and revising goals and targets for future reductions.

Emissions inventories provide a snapshot of the amount and source of greenhouse gas emissions in a given year. The base year inventory serves as a reference point against which future performance and progress can be monitored and can help to assess the effectiveness of City strategies and actions.

1.4.3 Overview of the GHG Inventory Methodology

The 2015 Community Inventory adheres to guidance provided in the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* (GPC).¹⁴ The GPC is a highly respected protocol with established and well-vetted methodological guidelines. Prior to publication of the GPC in 2014, cities developed GHG emission inventories using a variety of protocols, making comparison of inventory results both year-over-year within the same city, as well as between cities, difficult. The GPC, first published in 2014, is the first protocol to provide “a consistent, transparent and internationally recognized approach for cities to measure and report emissions, allowing for credible comparison and aggregation across timescales and geographies.”¹⁵ The Compact of Mayors requires signatories such as Chicago to complete GHG emission inventories using the GPC.

The City of Chicago's previous GHG emission inventories were conducted prior to publication of the GPC, and therefore used a variety of protocols according to best practice at the time of completion. For this 2015 GHG inventory and future inventories, the City of Chicago will use the GPC to enable consistent, transparent and comparable GHG inventories over time to track effectiveness of GHG reduction strategies implemented in Chicago. To ensure comparability between past inventory years and the 2015 inventory, the City also updated the 2005 and 2010

¹⁴ For more information about the GPC, visit the [Greenhouse Gas Protocol for Cities website](#).

¹⁵ C40 Programmes Measurement & Planning. C40. <http://www.c40.org/gpc>, accessed June 30, 2017.

inventories to be compatible with the GPC guidelines and use consistent methods. The results of the 2005 and 2010 inventory updates are provided later in this document.



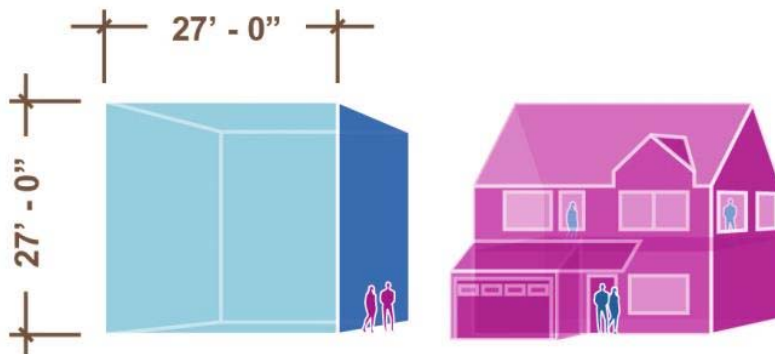
The GPC provides guidance on how to standardize community-scale emissions inventories.

The following sections give an overview of the emissions estimation process and sectors analyzed in each inventory. Additional details on the emissions reporting protocols, inventory methodologies, and data sources are provided in Appendix A.

1.4.4 How Are Emissions Measured?

Emissions inventories are commonly expressed in metric tons (or tonnes¹⁶) of carbon dioxide (CO₂) equivalent per year (MT CO₂e/year). Figure 2 illustrates the scale of one metric ton of carbon dioxide as compared to a single-family house to help put a metric ton of CO₂ in context.

Figure 2 – How Large is One Metric Ton of CO₂?



One metric ton of carbon dioxide would fill a cube 27 feet tall! That's about the size of a two-story home, totaling more than 1,400 square feet.

¹⁶ "tonne", also called a metric ton, is the standard international unit for measuring GHG emissions. It is different than a U.S. short ton (or "ton"). 1 U.S. short ton (ton) = 0.9072 metric tons (tonnes).

Carbon dioxide equivalent (CO₂e) is the universal unit for comparing emissions of different GHGs to CO₂ based upon the varying global warming potentials (GWP) of each gas.¹⁷ GWPs were developed by the Intergovernmental Panel on Climate Change (IPCC) and describe how much heat a GHG can trap in the atmosphere compared to carbon dioxide, which has a GWP of 1 (because it is the gas being used as the reference). The idea is to express the impact of each different GHG in terms of the amount of CO₂ that would create the same amount of warming so that an emissions inventory consisting of many different greenhouse gases can be expressed as a single number. For example, methane has a GWP of 28, which means that 1 metric ton of methane will trap 28 times more heat than 1 metric ton of carbon dioxide, making it a more potent greenhouse gas. Some gases used in industrial applications can have a GWP thousands of times larger than CO₂.

To maintain consistency within each inventory and between the baseline and subsequent emission inventories, all GHG emissions have been quantified in units of MT CO₂e/year. To obtain CO₂ equivalent emissions, the mass of each GHG is multiplied by its respective GWP¹⁸ and then added together to give CO₂e.

The 2015 emissions inventory was prepared using a combination of empirical (measured) and estimated (modeled) data, depending on the availability of data. Data were collected from many sources including City records and utility company reports. Activity data were then converted into greenhouse gas emissions estimates using relevant emissions factors. Emission factors relate the amounts of greenhouse gases emitted by an action to a set amount of activity under that action. For example, burning a ton of coal releases different totals of carbon dioxide, methane and nitrous oxide than burning a gallon of gasoline. The emission factors used in each equation define how much of each gas is released per a defined unit (such as a ton or gallon) as a result of that activity (in this case, burning coal or burning gasoline).

Emissions were calculated using the following equation:

$$\text{Amount of Activity} \times \text{Emissions Factor} = \text{GHG Emissions for the Action}$$

Where examples of activities include lighting homes and buildings, commuting, or treating wastewater, and the amounts of activity electricity consumed (i.e., kilowatt hours/year), vehicle miles traveled, and gallons of wastewater generated.

¹⁷ All seven GHGs that contribute to climate change covered by the Kyoto Protocol were included: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃). However, activities within the City of Raleigh emit only CO₂, CH₄, N₂O and HFCs. There were no emissions of PFCs or SF₆ identified in the emissions analysis as these emissions are generally associated with the transmission and distribution of electricity from generation facilities and/or the manufacture of semi-conductors. Fugitive emissions of HFCs are associated with refrigerant usage.

¹⁸ GWPs were sourced from the IPCC's 4th Assessment Report

1.4.5 What is Included in the Inventory?

The first step in developing a GHG inventory is to define the inventory boundary, i.e., the geographic area, along with the gases, and emission sources covered by a GHG inventory. GHG emissions can be described as direct or indirect, depending upon where the emissions generation occurs. In GHG accounting there are three ‘scopes’ of GHG emissions:



SCOPE 1 What we combust (e.g., natural gas, transport fuel)



SCOPE 2 Purchased emissions from energy we consume (e.g., grid supplied electricity)



SCOPE 3 Other indirect emissions (e.g., waste disposal at third party landfills, electricity losses from energy transmission)

Scope 1 direct emissions are those where the source directly generates the emissions, such as combusting natural gas in a boiler for heating a building or an industrial process, or gasoline combustion by a bus. For a community inventory, the combustion takes place within the city boundary and the resulting emissions are a direct result of that consumption.

Scope 2 indirect emissions are those where the activity takes place within the city jurisdiction, but the actual emissions generation occurs outside of that boundary. By definition, Scope 2 is limited to purchased electricity and steam. For example, a Chicago resident can consume electricity within their home, but that electricity was generated in an area outside of the city’s jurisdiction (e.g., power plants throughout Illinois).

Scope 3 other indirect GHG emissions is an optional reporting category that allows for quantification of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the city, but occur from sources and activities outside the city boundary. Scope 3 emissions are often emissions that might be reported by other entities as Scope 1 emissions. For example, combustion of fuel on an airplane during the cruise portion of a flight to another city would be reported by the airline as Scope 1 emissions because they are responsible for burning the fuel, but the City might consider reporting emissions from airplanes during flights as Scope 3 because its citizens are using that mode of transportation and the City might want to more fully understand its broader GHG emissions impact.

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2 COMMUNITY INVENTORY

The 2015 Chicago Community-Scale GHG Inventory estimates the total amount of emissions generated from activities within the City of Chicago boundary. The inventory represents emissions from residential, commercial and institutional, industrial, and public activities. This section introduces the emissions sectors used to organize the community inventory. It then presents the 2015 year community inventory and describes sub-sector emissions, as necessary, to provide greater detail on how emissions are generated in the City of Chicago. Emissions trends compared to previous Chicago GHG inventories are then presented.

2.1 Inventory Boundary

The boundary for the 2015 GHG inventory is the City of Chicago's jurisdiction within Cook County. The city occupies a 237-square-mile area and is home to approximately 2.8 million citizens. The Chicago region has one of the world's largest and most diversified economies. Chicago is a transportation and distribution center and home to many major corporate headquarters, with manufacturing, printing, publishing, insurance and food processing also playing major roles in the city's economy. Two major airports, O'Hare and Midway, are located within the city boundary.

2.2 GHG Emission Sources

The inventory is organized into categories, or sectors, that represent the commonly understood, major sources of emissions. These sectors are defined in the GPC and include sub-sector activities. The City of Chicago's community inventory includes emissions from the following GPC Basic Level sectors and sub-sectors, which are described in further detail below:

- Stationary Energy
 - Residential Buildings
 - Commercial and Institutional Buildings
 - Manufacturing industries and construction
 - 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
 - Wastewater treatment and discharge

2.3 Scope Limitations

The inventory presented in this report covers all the GPC Basic level required emission sectors and sub-sectors. Due to data limitations, the inventory does not include emissions from the Industrial Process and Product Use (IPPU) and Agriculture, Forestry, and Other Land Use (AFOLU) sectors or scope 3 emissions in the Stationary Energy and Transportation sectors as outlined in the guidelines for GPC Basic+ level inventories. The difficulty in obtaining IPPU activity data makes this sector especially challenging to complete. Few peer cities have completed estimates of IPPU emission for this reason. Given the community's urban context, AFOLU emissions were determined to be negligible. In future emission inventories, the City will consider expanding the emissions inventory to include IPPU and the additional scope 3 Stationary Energy and Transportation emissions if the information would significantly benefit climate action planning and implementation efforts.

2.4 Emission Sectors and Sub-sectors

The community inventory is organized into the following sectors to describe the primary sources of emissions in the community. A supporting Technical Memorandum in Appendix A (provided under separate cover) provides additional details on these sectors, the emissions reporting methodology, and data sources used to guide preparation of this inventory.

2.4.1 Stationary Energy

The Stationary Energy sector includes emissions generated as a result of energy consumption in homes, offices, schools, stores, manufacturing facilities and other buildings within the community. Emissions result from the consumption of electricity from the local utility grid, as well as the direct (non-mobile) combustion of natural gas and fuel oil. This sector also includes energy-related emissions attributed to the community's share of wastewater treatment and potable water conveyance.

The Stationary Energy sector is organized into three sub-sectors: residential buildings, commercial and institutional buildings and manufacturing and construction industries. All of the City of Chicago's drinking water is sourced from Lake Michigan; the associated sourcing activities and therefore associated stationary energy emissions occur inside the city's boundary. Chicago's wastewater treatment conveyance occurs at Metropolitan Water Reclamation District facilities located both inside and outside the city's boundary; however, only one wastewater treatment plant, Calumet, is located within the City's boundary. Therefore, stationary energy emissions occurring as a result of wastewater treatment conveyance include emissions from the Calumet plant only.

2.4.2 Transportation

The Transportation sector represents mobile emissions associated with two sub-sectors, on-road vehicle use on community roadways and off-road equipment emissions (e.g., forklifts, lawnmowers). The community's on-road transportation emissions come from vehicle trips that begin and/or end within the City's boundaries. Pass-through trips (for example, non-local drivers on the Interstate) are not included within the emissions inventory because they do not occur as a result of community activity (e.g., jobs, retail or housing in Chicago). The community's off-road

transportation emissions account for mobile sources associated with construction, lawns/gardens, industrial manufacturing, commercial, retail, and railroads.

2.4.3 Waste

The Waste sector includes emissions associated with solid waste disposal and biological process emissions resulting from wastewater treatment (separate from the energy-related wastewater treatment emissions included in the Stationary Energy sector). Solid waste collected by both the Chicago Department of Streets and Sanitation (DSS) (for single-family residences) and by commercial haulers (for multi-family residences and commercial customers) in the community is sent to landfills outside of the City boundaries. No solid waste generated in the City of Chicago is sent to an incineration facility. Minimal tonnage of yard waste collected in Chicago by the DSS is composted within Illinois; neighborhood organics composting programs at this time are small and not tracked by the City.

Waste collection and hauling activities also generate GHG exhaust emissions. However, hauling-related emissions from private haulers are assumed to be included within the transportation model and represented within the Transportation sector. While recycling of solid waste also produces greenhouse gas emissions, these emissions have not been included in the scope of this inventory due to the complexity involved in producing an emissions estimate and the likelihood they would not significantly impact the overall outcome of the inventory.

Treating wastewater generates nitrous oxide (N₂O) and methane (CH₄) emissions. The majority of emissions related to wastewater treatment result from the use of electricity, however, electricity related emissions are considered in the Stationary Energy Sector. This section refers only to direct emissions from the treatment processes that were employed at the Metropolitan Water Reclamation District's wastewater treatment plants.

2.5 Calendar Year 2015 GHG Emissions Inventory Results

As shown in Table 3 and Figures 3 through 6 on the following pages, community activities in the City of Chicago generated approximately 32,651,379 MT CO₂e in 2015. Stationary energy emissions were the largest contributor to the community inventory, accounting for 72% of total emissions. Transportation emissions contributed an additional 25%, with the waste sector responsible for the remaining 3% of community emissions.

Table 3 – 2015 Chicago GPC BASIC Community Greenhouse Gas Emissions Inventory by Sector and Sub-Sector

Sector	Emissions MT CO ₂ e/year				% of Total
	Scope 1 ^a	Scope 2 ^b	Scope 3 ^c	BASIC Total	
Stationary Energy	9,018,535	14,481,547	0	23,500,082	72.0%
Residential Buildings	5,264,148	3,863,687		9,127,835	28.0%
Commercial and Institutional Buildings and Facilities	2,699,359	5,679,497		8,378,856	25.7%
Manufacturing Industries and Construction	781,710	4,811,717		5,593,427	17.1%
Energy Industries	28	NA		28	0.0%
Water Conveyance and Treatment	46,774	51,554		98,327	0.3%
Calumet WWTP Wastewater Conveyance	2,390	75,093		77,482	0.2%
Fugitive Emissions from Oil and Natural Gas Systems	224,126	NA		224,126	0.7%
Transportation	7,763,715	284,748	0	8,048,463	24.6%
On-road Transportation	5,100,066	NA		5,100,066	15.6%
Railways	109,459	284,748		394,207	1.2%
Waterborne Navigation	4,366	NA		4,366	0.0%
Aviation	1,551,941	NA		1,551,941	4.8%
Off-road Transportation	997,883	NA		997,883	3.1%
Waste	2,235	0	1,100,599	1,102,834	3.4%
Solid Waste Generated in the City	NO		998,888	998,888	3.1%
Biological Waste Generated in City	NO		112	112	0.0%
Wastewater Treatment and Discharge	2,235		101,599	103,835	0.3%
TOTAL	16,784,486	14,766,295	1,100,599	32,651,379	100.0%

Key:

- ^a Scope 1 emissions are GHG emissions from sources located within the city boundary
- ^b Scope 2 emissions are GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary
- ^c Scope 3 emissions are all other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary

Figure 3 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Percent of Total Emissions by Sector

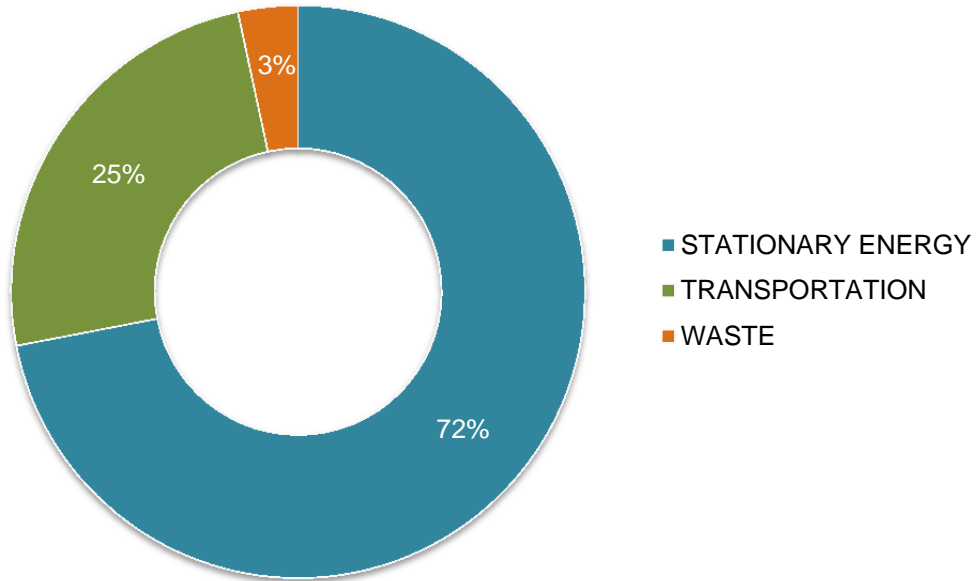


Figure 4 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Total Emissions by Sector

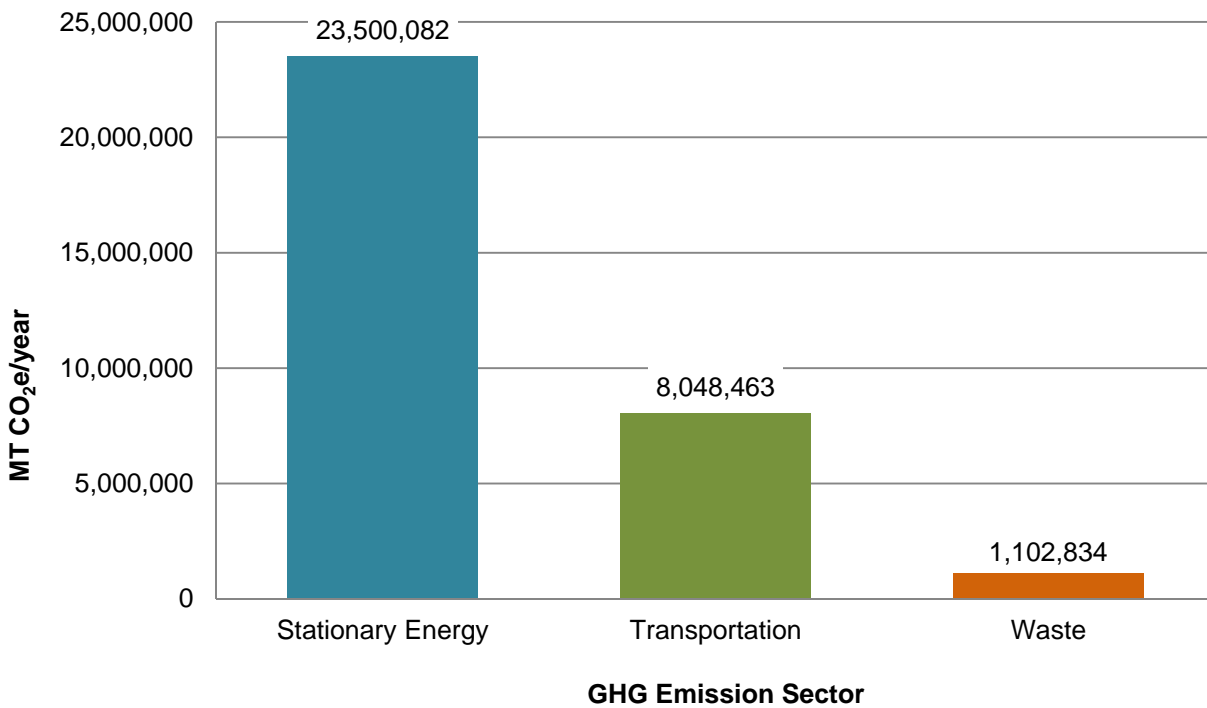


Figure 5 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Percent of Total Emissions by Sub-Sector

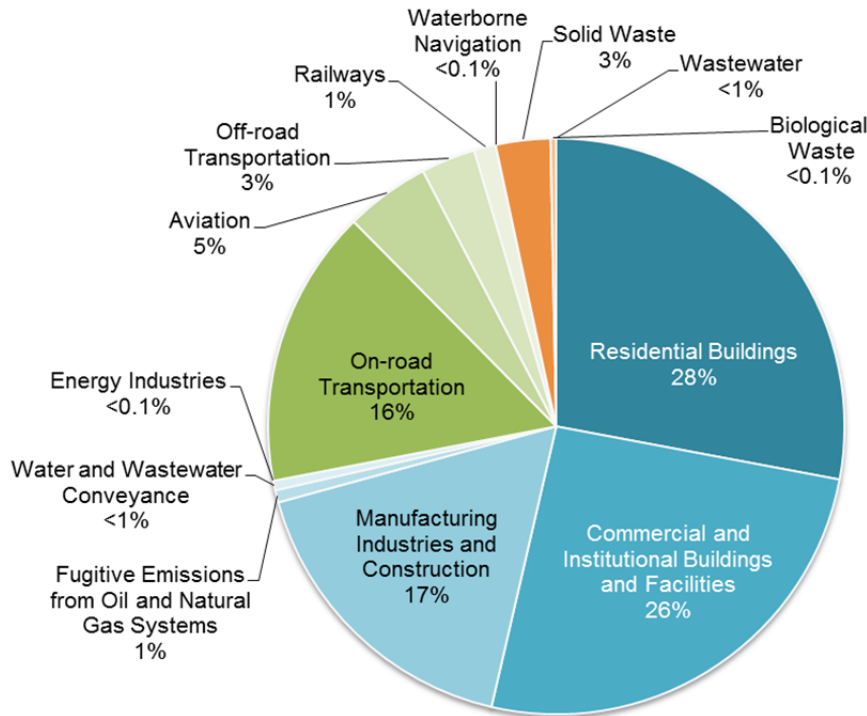
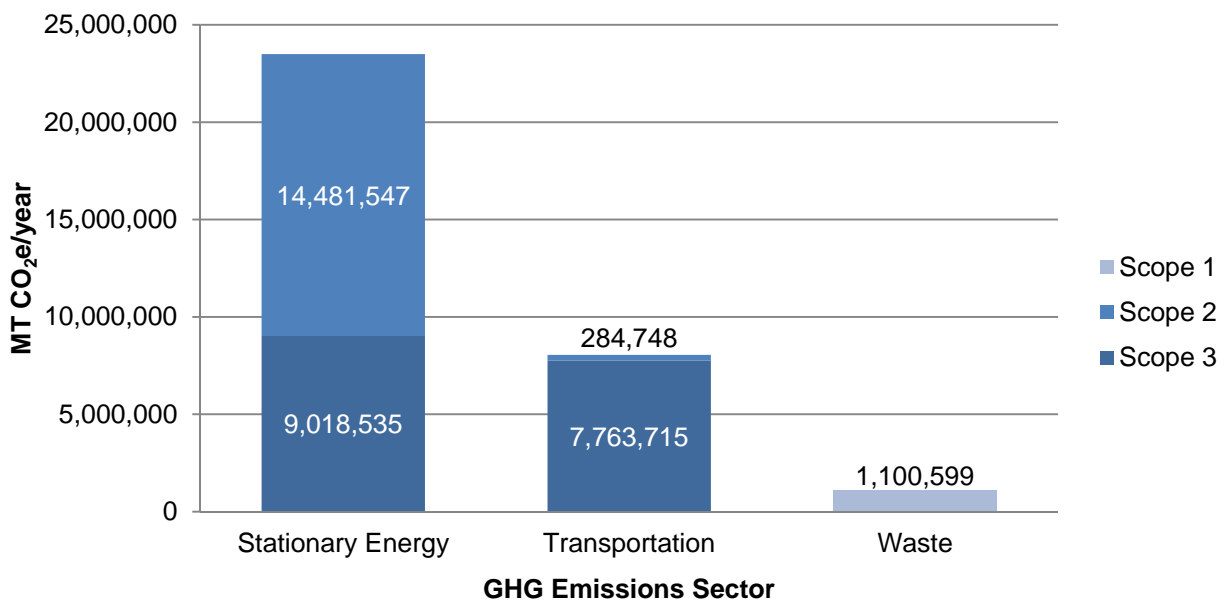


Figure 6 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Total Emission by Sector and Scope

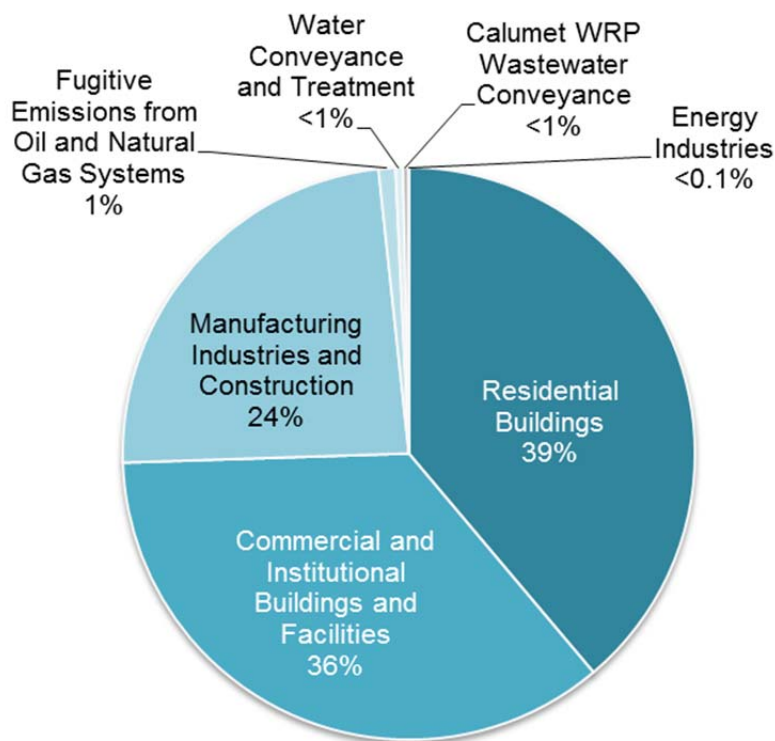


The following pages provide greater detail on the distribution of emissions within each sector. Emissions are represented according to sectors, sub-sectors and fuel-type.

2.6 Stationary Energy

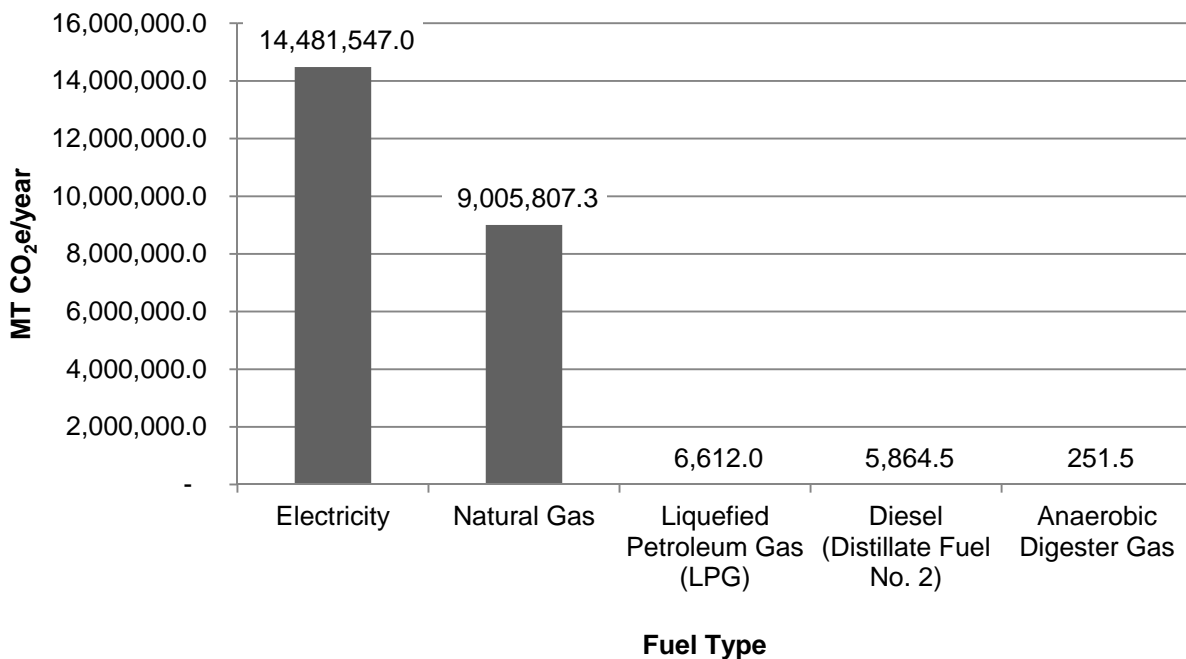
Stationary energy related emissions from buildings account for 72% of total community emissions. Residential buildings generate approximately 39% of the stationary energy sector emissions, commercial and institutional buildings provide an additional 36%, and manufacturing and construction industries contribute 24% of sector emissions. The remaining stationary energy sector emissions include fugitive emissions from oil and natural gas distribution systems (1%), water and wastewater conveyance (<1%), energy consumption at the Calumet Water Reclamation Plant (WRP) (<1%), and energy industries (<0.01%) as shown in Figure 7.

Figure 7 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Percent of Total Stationary Energy Sector GHG Emissions by Sub-Sector



The stationary energy sector can also be analyzed according to the type of energy used (Figure 8). Electricity use (Scope 2) was the largest source of GHG emissions in the stationary energy sector, generating 62% of the sector’s emissions. Natural gas combustion and fugitive emissions (Scope 1) contributed 38%. The remaining emissions (0.06%) were the result of combusting diesel fuel (distillate fuel oil No. 2), liquefied petroleum gas (LPG), and anaerobic digester gas at the Calumet WRP.

Figure 8 – 2015 Stationary Energy Emissions by Fuel Type

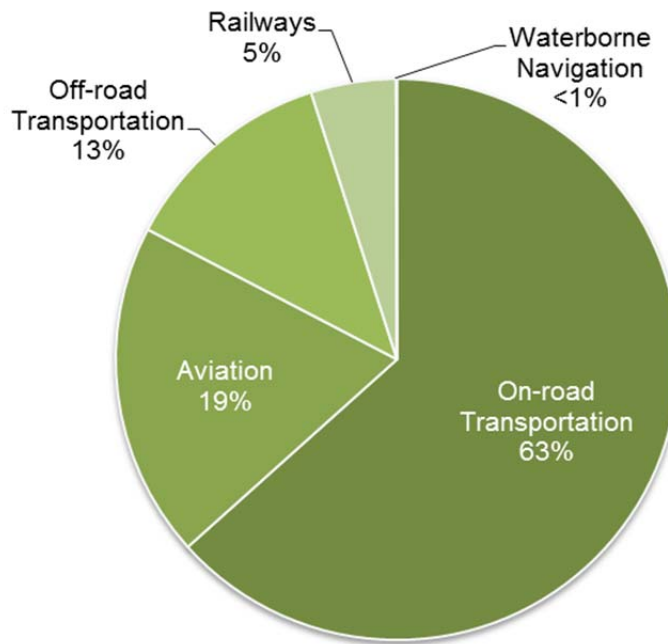


Electricity use by the commercial and institutional sub-sector contributed 24% of the total stationary energy sector emissions, while the manufacturing industries and construction sub-sector contributed approximately 20% and residential buildings contributed 16%. Natural gas use by the residential sub-sector contributed 22%, commercial and institutional buildings contributed 11% and manufacturing industries and construction contributed 3% of the total stationary energy sector emissions. The water conveyance and wastewater stationary energy contribution to the stationary energy sector is less than 1% in both electricity and natural gas usage.

2.7 Transportation

Transportation sector emissions account for 25% of total community emissions. As shown in Figure 9, the majority of transportation emissions come from on-road vehicles driving on roadways within the community (63%). Aviation accounts for 19% of transportation emissions. Off-road equipment, such as lawnmowers, forklifts, construction equipment, and railway operations provide an additional 13% of sector emissions. Operation of railways within the community, including Amtrak, CTA Rail, Metra Rail, and Northern Indiana Commuter Transportation District, contribute approximately 5% of sector emissions, and waterborne navigation represents the remainder (<1%).

Figure 9 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Percent of Total Transportation Sector GHG Emissions by Sub-Sector

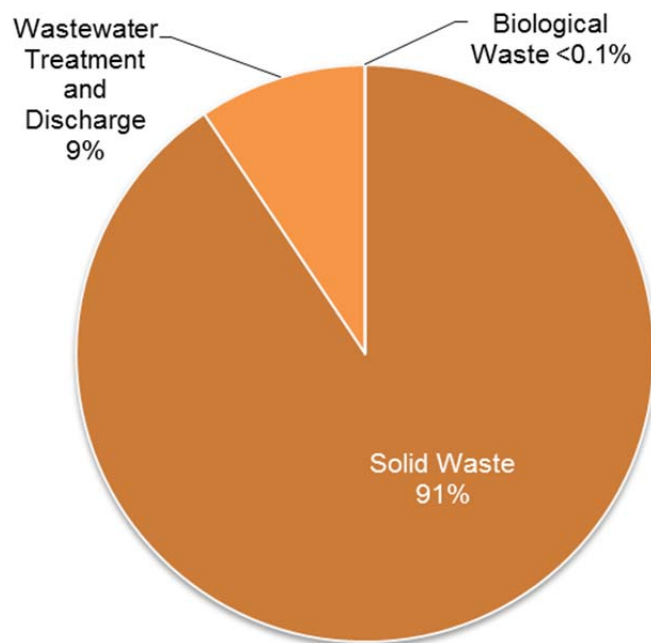


The majority of transportation emissions come from on-road vehicles driving on roadways within the community (63 percent).

2.8 Waste

Accounting for only 3% of total community emissions, the Waste sector includes emissions from solid waste landfilling, biological treatment, and also the biological process emissions related to wastewater treatment. The majority of waste sector emissions are due to the landfilling of the city's solid waste (91%), while fugitive emissions from the wastewater treatment plants constitute 9% and biological treatment less than 1% of the waste sector emissions as shown in Figure 10.

Figure 10 – 2015 Chicago GPC BASIC Community GHG Emissions Inventory – Percent of Total Waste Sector GHG Emissions by Sub-Sector



3 EMISSIONS TRENDS

City of Chicago community greenhouse gas emissions have decreased from 2005 to 2015 as shown in Figure 11 and Table 4 (on following page). While emissions from interim years have not been quantified, the three inventories indicate a steady decline in emissions during this period. Between 2005 and 2010, total emissions decreased by 4.6% or by 0.9% per year. From 2005 to 2015, total emissions decreased by 11.0%. Between 2010 and 2015, the emissions decreased at a rate of 1.4% per year.

Figure 11 – Community GHG Emissions 2005, 2010, 2015

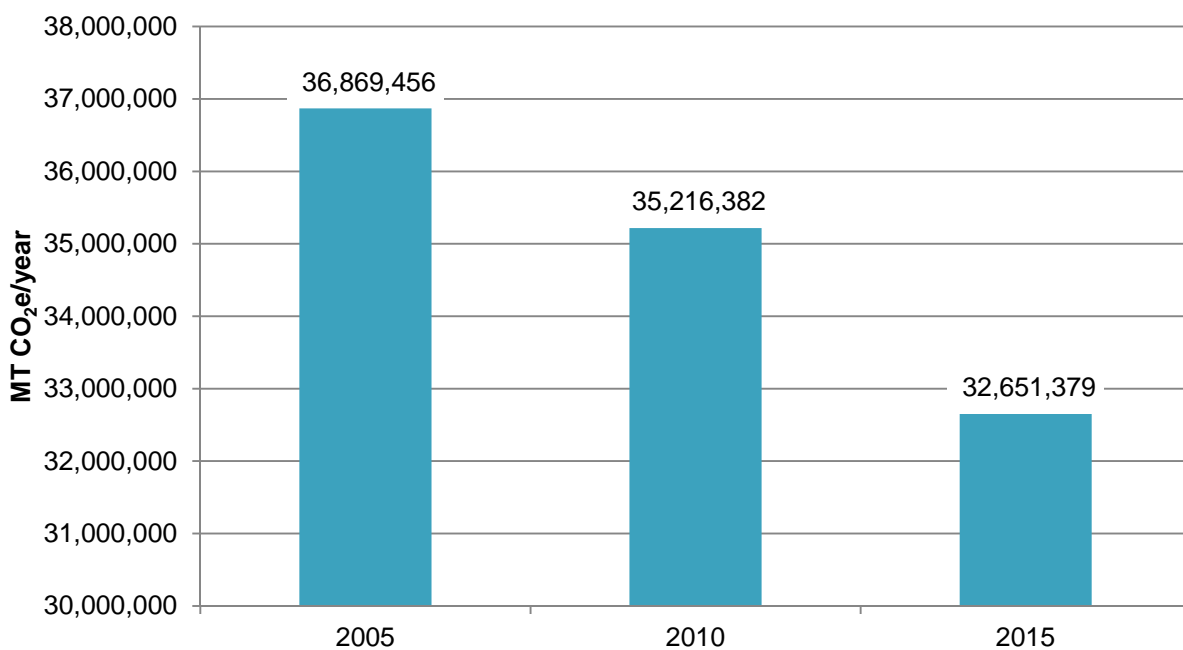


Table 5 on the following page demonstrates that while the overall emissions decreased, the relative distribution of emissions by sub-sector changed minimally between the three inventory years.¹⁹ In each inventory, the largest sources of emissions are the commercial (I.2) and manufacturing (I.3) energy, residential energy (I.1) and on-road transportation energy (II.1) sub-sectors. Other more moderate sources of emissions include the aviation energy (II.4), off-road transportation vehicles (II.5), solid waste landfills (III.1), and railway energy (II.2) sub-sectors. The following sections describe the specific changes that occurred within each sub-sector.

¹⁹ The most notable change is the reduction in commercial and manufacturing (I.2 and I.3) emissions between 2005 and 2010 and then again in 2015.

Table 4 – Emissions Inventory 2005, 2010, and 2015

Sector	2005 (MT CO₂e/year)	2010 (MT CO₂e/year)	2015 (MT CO₂e/year)
Stationary Energy	26,982,932	25,362,795	23,500,082
Residential Buildings	8,785,240	9,815,020	9,127,835
Commercial and Institutional Buildings and Facilities and Manufacturing Industries and Construction ²⁰	17,868,978	15,088,042	13,972,283
Energy Industries	30	21	28
Water Conveyance and Treatment	Included Elsewhere	145,262	98,327
Calumet WWTP Energy Use	77,708	91,359	77,482
Fugitive Emissions from Oil and Natural Gas Systems	250,975	223,091	224,126
Transportation	8,197,126	7,948,817	8,048,463
On-road Transportation	5,230,518	5,081,092	5,100,066
Railways	407,750	408,206	394,207
Waterborne Navigation	4,566	4,343	4,366
Aviation	1,736,673	1,551,247	1,551,941
Off-road Transportation	817,618	903,930	997,883
Waste	1,519,970	1,710,357	1,102,834
Solid Waste Generated in the City	1,317,550	1,542,561	998,888
Biological Waste Generated in the City	0	25	112
Wastewater Treatment and Discharge	202,420	167,771	103,835
Total	36,700,027	35,021,969	32,651,379

Table 5 – Distribution of Community GHG Emissions by Sub-Sector 2005, 2010, 2015

Emission Sub-Sector	2005	2010	2015
Residential Buildings	23.9%	28.0%	28.0%
Commercial and Manufacturing	48.7%	43.1%	42.8%
Fugitive Emissions from Natural Gas Systems	0.7%	0.6%	0.7%
Water and Wastewater Conveyance	0.2%	0.7%	0.5%
Energy Industries	<0.1%	<0.1%	<0.1%
On-road Transportation	14.3%	14.5%	15.6%
Aviation	4.7%	4.4%	4.8%
Off-road Transportation	2.2%	2.6%	3.1%
Railways	1.1%	1.2%	1.2%
Waterborne Navigation	<0.1%	<0.1%	<0.1%
Solid Waste	3.6%	4.4%	3.1%
Wastewater	0.6%	0.5%	0.3%
Biological Waste	0.0%	<0.1%	<0.1%

²⁰ The Commercial and Institutional Buildings and Facilities and the Manufacturing Industries and Construction subsectors are combined.

3.1 Stationary Energy

3.1.1 Electricity Emission Factor

Emissions are calculated by multiplying the amount of activity (e.g., total kilowatt hours consumed per year) occurring in a community by an activity-specific emission factor (e.g., tonnes of carbon dioxide equivalent per kWh). A change in emissions can be achieved through a change in activity or a change in the emission intensity of the emission factor. As is common practice in community-scale inventories, the City chose to hold the stationary energy sector fossil fuel combustion-related emission factors constant for all three inventories. For this reason, changes in fossil fuel combustion-related emissions between 2005, 2010, and 2015 result solely from changes in activity levels.

The emission factor for electricity is variable. An electricity emission factor is an aggregate emission factor that reflects the diversity of generation sources (fuel and technologies) used to produce the community's electricity. To ensure comparability between the three inventories, the City chose to use the United States Environmental Protection Agency's (U.S. EPA) electricity emission factor for the grid region within which Chicago is located. Table 6 demonstrates the decline in carbon emissions intensity of Chicago's electricity, which decreased by 2.2% from 2005 to 2010 and by 10.2% between 2005 and 2015. The lower electricity emission factor is an important driver for reduced stationary energy emissions in the community.

Table 6 – U.S. EPA eGrid for RFCW Sub-region Electricity Emission Factor 2005, 2010, 2015

Metric	2005	2010	2015	Unit
Electricity Emission Factor	1,545.14	1,510.54	1,390.94	lbs CO ₂ e/MWh
% Change from 2005	NA	-2.2%	-10.2%	percentage

3.1.2 Residential Energy

Total residential energy emissions increased by 11.7% from 2005 to 2010. Tables 7 through 9 on the following page demonstrate that while electricity emissions and consumption decreased during this period, increased natural gas consumption drove an overall increase in emissions in the sub-sector.

In 2015, total residential energy emissions were 3.9% above 2005 levels. This level of emissions is lower than the 2010 level due to a small reduction in natural gas consumption (compared to 2010), a steady decrease in residential electricity consumption and the lower electricity emission factor described above.

It should be noted that Table 7 demonstrates that residential energy emission intensity is higher in 2010 (3.64 MT CO₂e/capita) and 2015 (3.36 MT CO₂e/capita) than in 2005 (3.09 MT CO₂e/capita). As residential energy represents a large portion of the community's emissions and as emission reduction efforts are increasingly looking at emission intensity type targets, this may indicate an area that needs additional analysis as household natural gas consumption and the

related emissions have increased from 2005 levels.²¹ Determining the cause(s) of this increase could assist in future emission reduction efforts.

Table 7 – Residential Energy GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	8,785,240	9,815,020	9,127,835
Change from 2005 (MT CO ₂ e/year)	NA	1,029,779	342,595
% change from 2005	NA	11.7%	3.9%
Emission Intensity (MT CO ₂ e/capita)	3.09	3.64	3.36

Table 8 – Residential Energy GHG Emissions by Activity Type

Activity Type and Unit	2005	2010	2015
Natural Gas (MT CO ₂ e/year)	4,004,082	5,301,154	5,264,148
Electricity (MT CO ₂ e/year)	4,781,158	4,513,865	3,863,687

Table 9 – Residential Energy Activity by Activity Type

Activity Type and Unit	2005	2010	2015
Natural Gas (therms/years)	753,858,547	998,061,613	991,094,385
Electricity (kWh/years)	6,821,722,949	6,587,894,578	6,123,852,602

3.1.3 Commercial and Manufacturing

Due to the aggregation of commercial and manufacturing activity data by natural gas and electricity utilities in 2005, the City is unable to compare commercial (I.2) and manufacturing (I.3) emissions separately. Commercial and manufacturing emissions decreased by 15.6% by 2010 and by 21.8% in 2015 as compared to 2005. As demonstrated in Table 10, natural gas and electricity-related emissions decreased by almost 3 million MT CO₂e in 2010 and 4 million MT CO₂e in 2015 as compared to 2005, and made the commercial and manufacturing sub-sectors the largest source of reductions in both years. Between 2010 and 2015 commercial and manufacturing natural gas consumption stayed relatively steady while electricity consumption decreased by 3% and electricity-related emissions decreased by 10.3% due to the lower carbon electricity emission factor (see Tables 11 and 12).

²¹ The observed increase in natural gas consumption occurred even though 2005 and 2015 had a very similar number of heating degree days. In 2005, there were 6,098 heating degree days, in 2010 there were 5,991 heating degree days, and in 2015 there were 6,091 heating degree days. All three years were below the annual average of 6,339 heating degree days.

Table 10 – Commercial and Manufacturing Energy GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	17,868,978	15,088,042	13,972,283
Change from 2005 (MT CO ₂ e/year)	NA	-2,780,936	-3,896,696
% change from 2005	NA	-15.6%	-21.8%
Emission Intensity (MT CO ₂ e/capita)	6.29	5.60	5.14
Economic Efficiency (MT CO ₂ e/\$100k GDP)	3.68	2.90	2.18

Table 11 – Commercial and Manufacturing Energy GHG Emissions by Activity Type

Activity Type and Unit	2005	2010	2015
Natural Gas (MT CO ₂ e/year)	5,882,303	3,393,877	3,468,593
Gas Oil (MT CO ₂ e/year)	288	304	5,865 ²²
Liquefied Petroleum Gas (LPG) (MT CO ₂ e/year)	39	9	6,612 ²⁸
Kerosene (MT CO ₂ e/year)	102	397	0
Electricity (MT CO ₂ e/year)	11,986,247	11,693,455	10,491,213

Table 12 – Commercial and Manufacturing Energy Activity by Activity Type

Activity Type and Unit	2005	2010	2015
Natural Gas (therms/year)	1,107,475,838	638,973,741	653,040,645
Gas Oil (gallons/year)	28,069	29,647	572,556 ²⁸
LPG (scf/year)	255,100	60,144	42,741,383 ²⁸
Kerosene (gallons/year)	10,006	38,975	0
Electricity (kWh/year)	17,101,892,743	17,066,360,331	16,628,324,976

3.1.4 Wastewater and Water Energy

Energy-related wastewater and water conveyance (I.6) sub-sector emissions increased from 2005 to 2010 by 204.5% and from 2005 to 2015 by 126.2% (emissions decreased 25.7% between 2010 and 2015). These fluctuations in emissions likely resulted from changes in facility operations, which are normally implemented to improve water quality and other types of environmental performance. Many of these improvements may increase energy use, but reduce nitrogen and fugitive methane emissions, which are discussed below in the Wastewater Emission (III.4) section.

²² The considerable jump in commercial and manufacturing gas oil and LPG activity that occurred between 2010 and 2015 is likely due to a change in the US EPA mandatory emission reporting requirements. Data for some source categories are not directly comparable between 2010 and subsequent years. Twelve new source categories began reporting after 2010.

Table 13 shows that overall wastewater and water conveyance energy-related emissions increased more than two fold from 2005 to 2015. Table 14 shows that high levels of natural gas and electricity consumption are the drivers of this increase. This is the largest percent increase within any sub-sector emissions in the community, though the relatively small size of the sub-sector limits the impact it has on overall emissions.

Table 13 – Wastewater and Water Energy GHG Emissions 2005, 2010, 2015

Total Sub-Sector Emissions	2005	2010	2015
Emissions (MT CO ₂ e/year)	77,708	236,622	175,810
Change from 2005 (MT CO ₂ e/year)	NA	158,914	98,102
% change from 2005	NA	204.5%	126.2%
Emission Intensity (MT CO ₂ e/capita)	0.03	0.09	0.06

Table 14 – Wastewater and Water Energy GHG Emissions by Activity Type

Emissions by Fuel	2005	2010	2015
Natural Gas (MT CO ₂ e/year)	3,627	81,888	48,940
Sludge Gas (MT CO ₂ e/year)	573	638	223
Electricity (MT CO ₂ e/year)	73,507	154,095	126,646

3.1.5 Fugitive Natural Gas

Fugitive natural gas emissions are calculated in relationship to the amount of natural gas consumption. Total natural gas emissions decreased from 250,975 MT CO₂e in 2005 to 223,091 MT CO₂e in 2010 and 224,126 MT CO₂e in 2015 or approximately 11% below 2005 levels.

3.2 Transportation

3.2.1 On-Road Transportation

Emissions from on-road vehicles have changed very little between 2005 and 2015 as shown in Table 15 and Figure 12. Total on-road emissions have decreased by 2.9% from 2005 to 2010 and by 2.5% from 2005 to 2015. At the same time emission intensities within the sub-sector have increased slightly from 1.84 MT CO₂e/capita in 2005 to 1.88 MT CO₂e/capita and 1.87 MT CO₂e/capita in 2010 and 2015 respectively.

Table 15 – On-Road Transportation GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	5,230,518	5,081,092	5,100,066
Change from 2005 (MT CO ₂ e/year)	NA	-149,426	-130,452
% change from 2005	NA	-2.9%	-2.5%
Emission Intensity (MT CO ₂ e/capita)	1.84	1.88	1.87

Figure 12 – On-Road GHG Emissions 2005, 2010, 2015

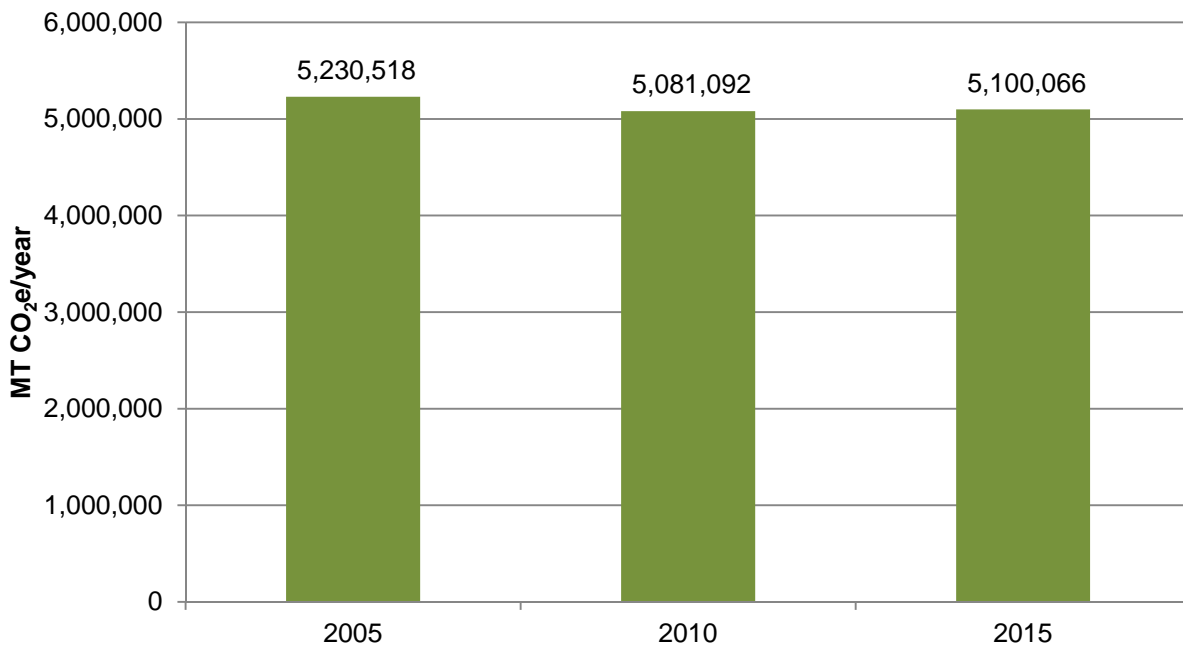


Table 16 shows that the majority of the emission reductions came from passenger cars and passenger trucks (i.e., SUVs) in both years. Emission increases came from commercial trucks. Tables 17 and 18 (on the following page) show that in 2010, the reductions came from reduced amounts of travel (vehicle miles traveled or VMT) in passenger cars and passenger trucks and from improved fuel efficiency. Many communities experienced a recession-driven reduction in passenger car and passenger truck VMT in 2010. Federal fuel efficiency requirements (CAFE standards) have steadily improved fuel efficiency in recent years. In 2015 VMT rebounded to levels above 2005 levels, but increased fuel efficiency (lower emission factors) resulted in on-road transportation sub-sector emissions staying stable.

Table 16 – On-Road Transportation GHG Emissions (MT CO₂e/year) by Vehicle Type in 2005, 2010, 2015

Vehicle Type	2005	2010	% Change from 2005	2015	% Change from 2005
Motorcycle	54,697	53,479	-2.2%	55,430	1.3%
Passenger Car	2,661,279	2,544,172	-4.4%	2,535,798	-4.7%
Passenger Truck	1,622,157	1,551,376	-4.4%	1,551,684	-4.3%
Light Commercial Truck	120,391	124,301	3.2%	125,037	3.9%
School Bus	60,059	64,422	7.3%	66,511	10.7%
Single Unit Short-haul Truck	243,541	248,941	2.2%	263,712	8.3%
Combination Short-haul Truck	440,759	465,231	5.6%	472,283	7.2%
Combination Long-haul Truck	27,635	29,170	5.6%	29,612	7.2%

Table 17 – On-Road Transportation Activity (vehicle miles traveled/year) by Vehicle Type in 2005, 2010, 2015

Vehicle Type	2005	2010	% Change from 2005	2015	% Change from 2005
Motorcycle	149,071,602	145,341,345	-2.5%	150,474,692	0.9%
Passenger Car	6,577,842,775	6,411,765,447	-2.5%	6,635,312,030	0.9%
Passenger Truck	2,963,938,867	2,889,105,359	-2.5%	2,989,834,189	0.9%
Light Commercial Truck	219,972,944	231,483,296	5.2%	240,925,040	9.5%
School Bus	60,758,821	65,324,071	7.5%	67,010,401	10.3%
Single Unit Short-haul Truck	207,395,590	213,710,546	3.0%	222,173,642	7.1%
Combination Short-haul Truck	233,721,111	246,759,230	5.6%	254,503,450	8.9%
Combination Long-haul Truck	14,654,140	15,471,620	5.6%	15,957,177	8.9%

Table 18 – On-Road Transportation Emission Factor (g/mile) by Vehicle Type in 2005, 2010, 2015

Vehicle Type	2005	2010	% Change from 2005	2015	% Change from 2005
Motorcycle	366.9	368.0	0.3%	368.4	0.4%
Passenger Car	404.6	396.8	-1.9%	382.2	-5.5%
Passenger Truck	547.3	537.0	-1.9%	519.0	-5.2%
Light Commercial Truck	547.3	537.0	-1.9%	519.0	-5.2%
School Bus	988.5	986.2	-0.2%	992.5	0.4%
Single Unit Short-haul Truck	1174.3	1164.8	-0.8%	1187.0	1.1%
Combination Short-haul Truck	1885.8	1885.4	0.0%	1855.7	-1.6%
Combination Long-haul Truck	1885.8	1885.4	0.0%	1855.7	-1.6%

It should be noted that the emission factor and vehicle mile traveled data shown above includes both gasoline and diesel vehicles within the same vehicle class. The Chicago Metropolitan Agency for Planning (CMAP) regional travel model does not analyze gasoline and diesel separately so the data shows the two fuels aggregated. Gasoline and diesel vehicle miles traveled are multiplied by a weighted composite (gasoline and diesel) emission factor.

3.2.2 Railways

Railway emissions remained virtually unchanged between 2005 and 2010 as shown in Table 19. Tables 20 and 21 (on the following page) show that minor increases in diesel and electricity consumption were offset by the lower 2010 electricity emission factor. Between 2005 and 2015 emissions fell by 3.3% even though diesel and electricity activity increased. The reductions resulted from the lower 2015 electricity emission factor.

Table 19 – Railways GHG Emissions (MT CO₂e/year) in 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	407,750	408,206	394,207
Change from 2005 (MT CO ₂ e/year)	NA	455	-13,543
% change from 2005	NA	0.1%	-3.3%
Per capita Emission (MT CO ₂ e/capita)	0.14	0.15	0.14

Table 20 – Railways GHG Emissions (MT CO₂e/year) by Activity Type in 2005, 2010, 2015

Emissions by Fuel	2005	2010	2015
Diesel (MT CO ₂ e/year)	97,112	101,741	109,459
Electricity (MT CO ₂ e/year)	310,639	306,465	284,748

Table 21 – Railways Activity in 2005, 2010, 2015

Activity by Fuel	2005	2010	2015
Diesel (gallons/year)	9,427,141	9,876,524	10,625,785
Electricity (kWh/year)	443,216,926	447,278,878	451,318,520

3.2.3 Waterborne Navigation

Waterborne navigation-related emissions decreased slightly in 2010 and 2015 from 2005 levels as shown in Table 22. Waterborne emissions by fuel type are shown in Table 23.

Table 22 – Waterborne GHG Emissions (MT CO₂e/year) in 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	4,566	4,343	4,366
Change from 2005 (MT CO ₂ e/year)	NA	-223	-201
% change from 2005	NA	-4.9%	-4.4%
Per capita Emission (MT CO ₂ e/capita)	<0.01	<0.01	<0.01

Table 23 – Waterborne GHG Emissions (MT CO₂e/year) by Activity Type in 2005, 2010, 2015

Emissions by Fuel	2005	2010	2015
Diesel (MT CO ₂ e/year)	1,138	1,083	1,088
Electricity (MT CO ₂ e/year)	3,428	3,260	3,277

3.2.4 Aviation

Aviation landing and takeoff (Scope 1) emissions decreased by approximately 11% from 2005 levels in 2010 and 2015 as shown in Table 24. This reduction was the result of reduced flight operations at O'Hare and Midway airports and corresponding reduction in jet kerosene consumption as shown in Tables 25 and 26 on the following page.

Table 24 – Aviation GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	1,736,673	1,551,247	1,551,941
Change from 2005 (MT CO ₂ e/year)	NA	-185,426	-184,732
% change from 2005	NA	-10.7%	-10.6%
Emission Intensity (MT CO ₂ e/capita)	0.61	0.58	0.57

Table 25 – Aviation Activity 2005, 2010, 2015

Activity Type and Unit	2005	2010	2015
Jet Kerosene (gallons/year)	180,304,277	161,053,007	161,125,100

Table 26 – Airport Operations Activity 2005, 2010, 2015

Activity by Airport	2005	2010	2015
O'Hare Airport (total operations/year)	972,246	882,617	875,136
Midway Airport (total operations/year)	290,756	245,533	253,519

3.2.5 Off-Road Vehicles

Off-road vehicle emissions increased by 10.6% from 2005 to 2010 and by 22.0% from 2005 to 2015 as shown in Tables 27 and 28. Due to the difficulty in estimating off-road emissions at the community scale, activity data was obtained from the U.S. EPA Motor Vehicle Emission Simulator (MOVES) model for all of Cook County and then downscaled for Chicago based on indicators such as construction and industrial employment and households. As a result there is a high degree of uncertainty regarding the accuracy of activity and emissions estimates for this sub-sector.

Table 27 – Off-Road GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	817,618	903,930	997,883
Change from 2005 (MT CO ₂ e/year)	NA	86,311	180,265
% change from 2005	NA	10.6%	22.0%
Per capita Emission (MT CO ₂ e/capita)	0.29	0.34	0.37

Table 28 – Off-Road GHG Emissions by Activity Type 2005, 2010, 2015

Activity Type and Unit	2005	2010	2015
Diesel (MT CO ₂ e/year)	486,356	552,571	618,633
Gasoline (MT CO ₂ e/year)	204,917	220,322	240,933
Liquefied petroleum gas (MT CO ₂ e/year)	117,740	121,382	130,214
Compressed natural gas (MT CO ₂ e/year)	8,605	9,655	8,103

3.3 Waste

3.3.1 Solid Waste

Between 2005 and 2010 solid waste emissions from material sent to landfills increased by 17.1% (see Table 29). Between 2005 and 2015 the same category of emissions fell by 24.2%. Table 30 shows that the amount of solid waste sent to landfills has decreased steadily from 2005 to 2010 (a 6.8% reduction) and from 2005 to 2015 (a 23.7% reduction). The increase in solid waste emissions in 2010 as compared to 2005 is due to the fact that approximately 2% of waste in 2010 was deposited in a landfill with no landfill gas (methane) capture system, resulting in the generation of considerable methane emissions. In the 2005 and 2015 inventories, it was determined that all waste was deposited at facilities with capture systems.

Table 29 – Solid Waste GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	1,317,550	1,542,561	998,888
Change from 2005 (MT CO ₂ e/year)	NA	225,011	-318,662
% change from 2005	NA	17.1%	-24.2%
Emission Intensity (MT CO ₂ e/capita)	0.46	0.57	0.37

Table 30 – Solid Waste Activity 2005, 2010, 2015

Activity Type and Unit	2005	2010	2015
Municipal Solid Waste (short tons)	3,111,920	2,901,689	2,373,832

3.3.2 Biological Treatment

Emissions related to composting (biological treatment) of organic waste materials increased from 2005 to 2010 and again to 2015 as the City initiated and expanded composting programs as shown in Tables 31 and 32.

Table 31 – Biological Treatment GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	0	25	112

Table 32 – Biological Treatment Activity 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Organic material composted (kg/year)	0	132,676	582,594

3.3.3 Wastewater

Wastewater emissions are directly correlated to the number of persons served, the types of technologies used to treat the sewage, and the facility operation conditions. As shown in Table 33, wastewater emissions decreased by 17.1% between 2005 and 2010 and by 48.7% from 2005 to 2015. The decrease can be explained by improvements made to treatment processes. Table 34 shows a decline in nitrogen emissions resulting from improved processes that remove nitrogen pollutants from wastewater effluent. Changes in systems and operations led to a considerable decrease in fugitive methane emissions from 2005 to 2010 and 2015.

Table 33 – Wastewater GHG Emissions 2005, 2010, 2015

Metric and Unit	2005	2010	2015
Emissions (MT CO ₂ e/year)	202,420	167,771	103,835
Change from 2005 (MT CO ₂ e/year)	NA	-34,649	-98,585
% change from 2005	NA	-17.1%	-48.7%
Emission Intensity (MT CO ₂ e/capita)	0.07	0.06	0.04

Table 34 – Wastewater Activity 2005, 2010, 2015

Activity Type and Unit	2005	2010	2015
Nitrogen (MT CO ₂ e/year)	38,626	36,348	30,692
Fugitive Methane (MT CO ₂ e/year)	163,794	131,423	73,142

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4 RECOMMENDATIONS FOR FUTURE INVENTORY UPDATES

4.1 Recommendations

Emissions inventories are prepared with the best currently available data at the time, and opportunities exist to improve inventories as additional information becomes available. The City should consider the following recommendations to improve the quality of future GHG inventories. Recommendations are grouped by sector and sub-sector.

4.1.1 Sector: Stationary Energy

Water conveyance and treatment-related electricity and natural gas combustion

The 2015 inventory accounts for electricity and natural gas consumption from City-operated water conveyance pumps and treatment stations. However, it is difficult to directly measure the portion of energy consumption attributable to customers within the boundaries of Chicago versus those in suburban areas, and therefore a scaling factor is used based on guidance from Chicago DWM.

Recommendation: *For future inventories, the City may consider working with Chicago Department of Water Management to more directly measure the amount of energy used for water conveyance and treatment.*

Energy Generation and Transmission-and-Distribution-related natural gas losses

The 2015 inventory accounts for emissions from energy industry related fuel combustion and fugitive natural gas emissions from transmission and distribution losses through information extracted from the EPA FLIGHT database. Under the current federal administration, it is unclear if this database will continue to be maintained in future years. Further, in the case of stationary combustion activities, the database only reports direct emissions and does not provide information on activity data contributing to emissions.

Recommendation: *For future inventories, the City may consider working with regional or State agencies to develop an alternative mechanism for industrial entities to report activity data and GHG emissions.*

4.1.2 Sector: Transportation

On-road transportation

The 2015 inventory accounts for emissions from all on-road vehicle activity occurring within the boundaries of Chicago. Emissions from this sub-sector were calculated using VMT and emission factors provided by CMAP broken down by vehicle type. The VMT and emission factor datasets were aggregated across fuel categories (i.e., not broken down by fuel types like gasoline, diesel, CNG), and the emission factors dataset was not broken down by speed bin.

Further, the EPA MOVES model used by CMAP to run the analysis is prone to updates and changes in methodology.

Recommendation: *For future inventories, the City may consider engaging CMAP early in the inventory process such that more granular datasets can be obtained from the agency on VMT and emission factors broken down by speed bin, vehicle type, and fuel type. Furthermore, it is recommended that the City collaborate closely with CMAP to understand future potential changes to the agency's transportation demand models and methodology used to produce outputs, such that the City can use a consistent methodology to track trends in VMT and emission factors in future inventories.*

Rail and Off-road vehicles

The 2015 inventory accounted for emissions from fuel consumed by rail-based and off-road vehicle activities. For the rail sub-sector, activity data on fuel consumed by rail service providers were obtained either from the National Transit Database (NTD) or agency reports and needed to be scaled down using assumptions to determine the portion of agency-wide fuel combustion activity attributable to Chicago. For the off-road vehicles sub-sector, county-wide emissions estimates for off-road vehicles were obtained from the EPA MOVES model and similarly scaled down to the city level. Furthermore, the EPA MOVES model off-road module only provides direct emissions output data and not activity data.

Recommendation: *In future inventories, the City may consider working with respective rail agencies to directly monitor rail activities serving the City of Chicago. Alternatively, the assumptions used to determine scaling factors could be further refined. In addition, the City could work with EPA staff to obtain activity data on off-road vehicles and also to refine scaling factors used to determine off-road vehicle activities in Chicago.*

Waterborne emissions

The 2015 inventory included emissions from water-borne navigation activity in Chicago. Emissions were calculated based on fuel consumption data provided by multiple water-based recreational service providers, such as tour companies. The data collection and conditioning process was time-intensive and it is unclear if all applicable service providers were accounted for in the inventory.

Recommendation: *In future inventories, the City may consider developing a list of all applicable service providers and establishing a line of communication with them early in the process, particularly if the City plans on conducting periodic inventories and anticipates issuing similar data requests in the future. The City could work with these companies to develop a standardized data collection template to streamline future efforts.*

Aviation emissions

The 2015 inventory included Scope 1 (Landing and Take Off) and Scope 3 (Cruise/Destination) emissions from aircraft-related operations activity occurring at O'Hare and Midway airports. Fuel consumption activity for O'Hare was obtained from the O'Hare Airport Modernization Environmental Impact Study report and estimated for Midway using Federal Aviation Administration flight data as the scaling factor. The estimation for Midway aircraft fuel consumption is a rough approximation and could be improved.

Recommendation: *In future inventories, the City may consider conducting airport specific analyses of aircraft fuel consumption. To facilitate annual monitoring of aviation emissions, the City could develop a simplified model based on Airport Cooperative Research Program inventory guidelines that City staff could use to cost efficiently estimate emissions at both the O'Hare and Midway airports.*

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