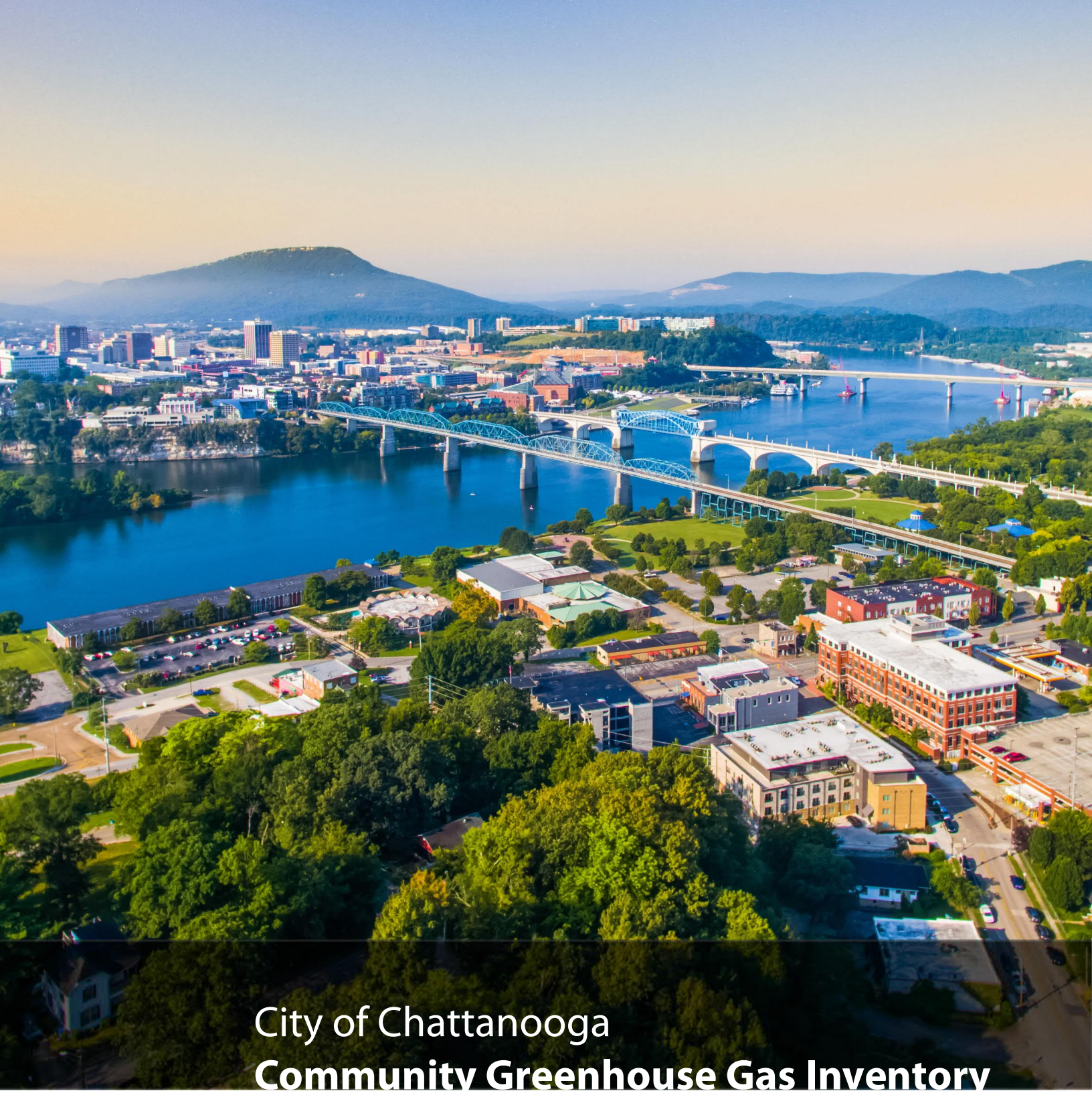


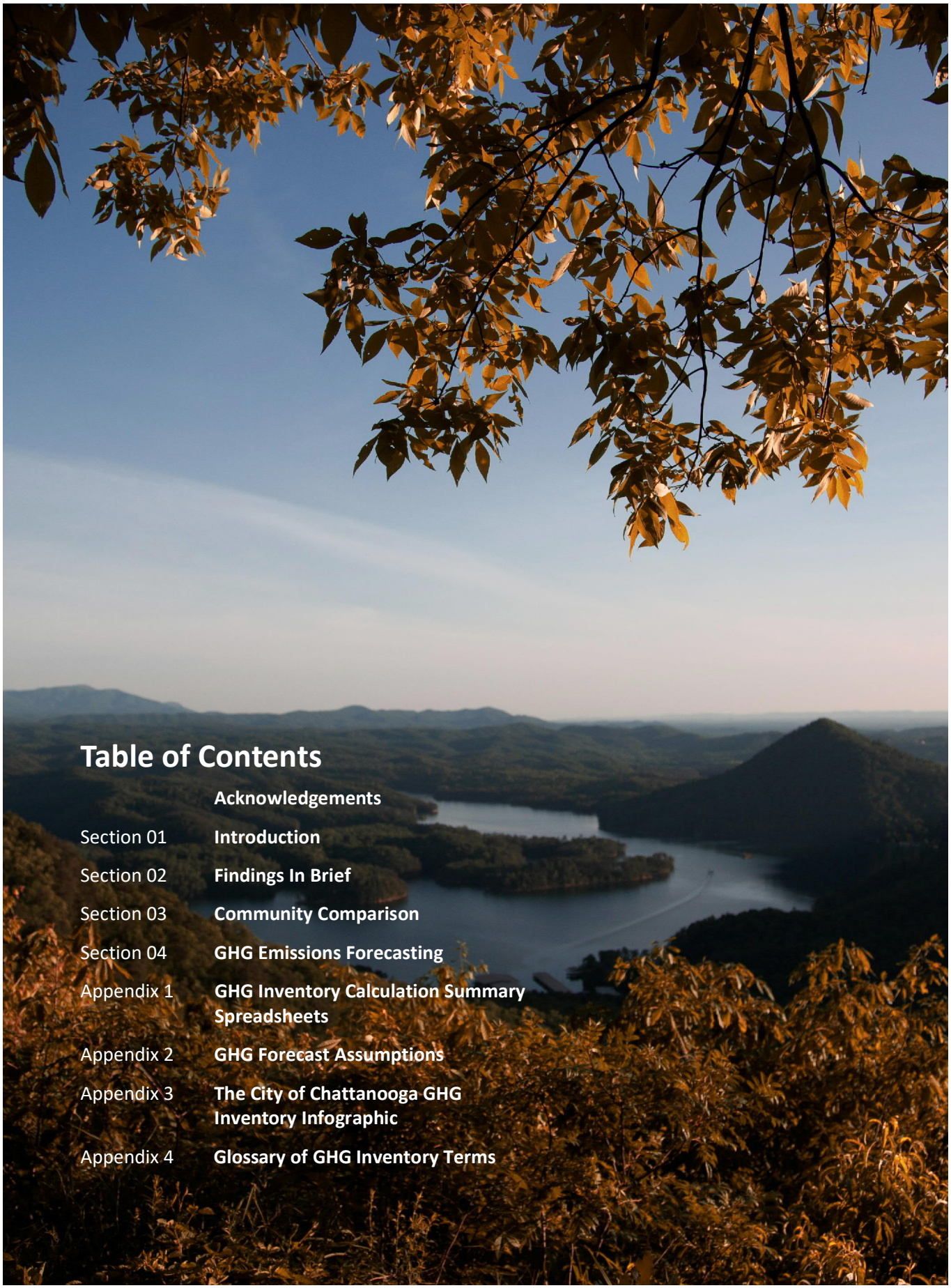
City of Chattanooga

Community Greenhouse Gas Inventory

June 2020

Prepared By:

making change personal paleBLUEdot LLC



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Acknowledgements

Thank you to the following organizations and individuals for their contributions:

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Section 01

Introduction

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Introduction

Background

The City of Chattanooga is committed to the advancement of sustainable projects and solutions through local and national initiatives which conserve resources, protect the environment, advance sustainability and support current and future residents of the city of Chattanooga and the state of Tennessee.

In 2009 the City of Chattanooga created its first Climate Action Plan. This Community Greenhouse Gas Inventory is a continuation of the City's on-going climate and sustainability commitments.

green|spaces

This GHG inventory was funded by Greenspaces Chattanooga. Since 2007, green|spaces has been helping advance the sustainability of living, working and building in Downtown Chattanooga and throughout the region. Their programs have helped Chattanooga claim the highest percentage of LEED-certified square feet per capita in the state of Tennessee. In addition to their resource center on Main St, green|spaces' green|light program helps local businesses improve the sustainability of their daily routines and save money in the process, their NextGen Homes are a demonstration development of net zero energy residential construction in the Northshore neighborhood and with Empower Chattanooga they are educating low-income neighborhoods about no-cost and low-cost ways of lowering their electric bills.

> "
>
> Without data, you're just another person with an opinion.
> W. Edwards Deming, Engineer, Professor, and Management Consultant

Project Overview

green|spaces contracted with paleBLUEdot LLC team to prepare community wide greenhouse gas GHG) inventories for the years 2008, 2013, and 2018. In addition, the paleBLUEdot team was asked to prepare a long-range "Business-as-usual" GHG forecast to identify potential long-term emissions trends. This report summarizes the results of those inventories.

Introduction

The Value of The City of Chattanooga Community Greenhouse Gas Inventories

The goal of the city of Chattanooga community wide inventory is to estimate the GHG emissions associated with the activities of the people who live, work, learn, travel, visit, and recreate within the city's geographical boundaries during three study years, 2008, 2013, and 2018. These inventories must be transparent and able to be replicated, updated, and compared with future assessments Chattanooga and assessments for peer cities.

Measuring the energy aspects of human activities and the associated GHG emissions offers a unique way to compare the effectiveness of various energy and sustainability best management practices. Greenhouse gas emissions and energy[1] serve as common denominators for the comparison of kilowatts of electricity, natural gas therms, tons of coal, and gallons of liquid fuels consumed; as well as vehicle miles traveled, tons of waste processed, and gallons of potable water distributed.

Every city prepares annual operating and capital improvement budgets. These assessments can be thought of as an assessment of the environmental budget for City operations. Recording these performance metrics is essential to promoting efficiency and sustainable change. Along with providing statewide benefits, these GHG assessments will:

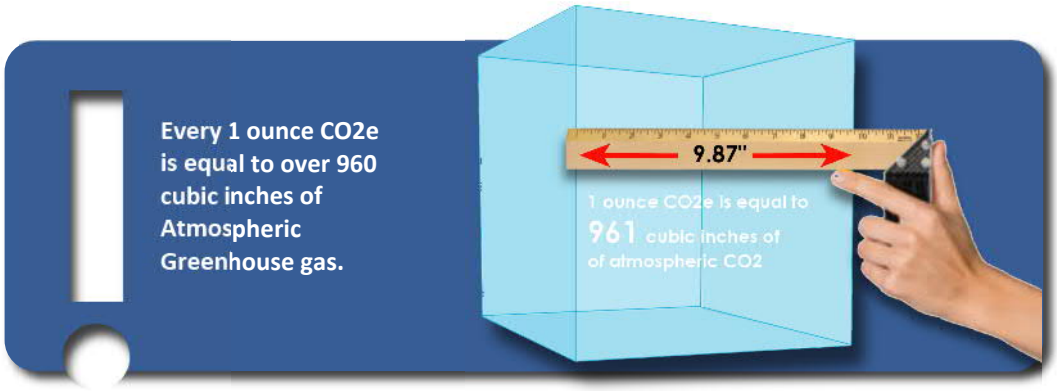
- Support identification of opportunities to save resources and money.
- Provide a baseline for estimating the effectiveness of many sustainability measures.
- Inform subsequent analyses, plans, and policy decisions.
- Improve the City's competitiveness for federal and state funding opportunities that are targeted to cities that have taken steps to measure and improve their energy efficiency and reduce their carbon footprints.
- Assist in promoting public understanding of the City's effects on climate change.
- Serve as a model for other cities.

The Carbon Cycle and the Role of Greenhouse Gases

The Carbon Cycle is exchanged among the oceans, atmosphere, and ecosystem. This cycle has been a closed, balanced system for hundreds of thousands of years. This cycle is present in the atmosphere primarily as carbon dioxide and methane. These two primary greenhouse gases uniquely allow light to pass while capturing infrared energy. This "Greenhouse Effect" directly impacts Earth's atmospheric energy and temperatures – without the historic levels of greenhouse gases present in the atmosphere, the average surface temperature of the Earth would be 0 degrees Fahrenheit.

Graphic Representations

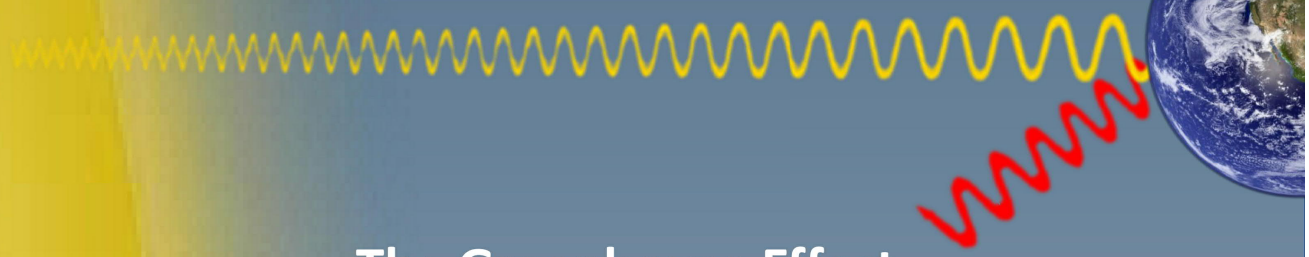
Greenhouse Gas Inventories quantify gas emissions in terms of weight - typically Metric Tons. It is important to understand that these references refer to gaseous pollution emissions which enter and occupy Earth's atmosphere. To help facilitate an increased awareness of the order of magnitude our collective GHG emissions represent, some of the emissions data reported in this report are also graphically represented in terms of volume of atmosphere. These volumes illustrate the amount of atmospheric space the referenced greenhouse gas emissions will occupy where they will remain, actively impacting our climate for as long as 200 years.



[1] Energy is expressed as kBtu (a thousand British thermal units) or MMBtu (a million Btus).

GHG's Impact on Our Climate

When sunlight strikes the Earth, it warms the surface and becomes heat energy – or **infrared energy**. This infrared energy then radiates back towards space.



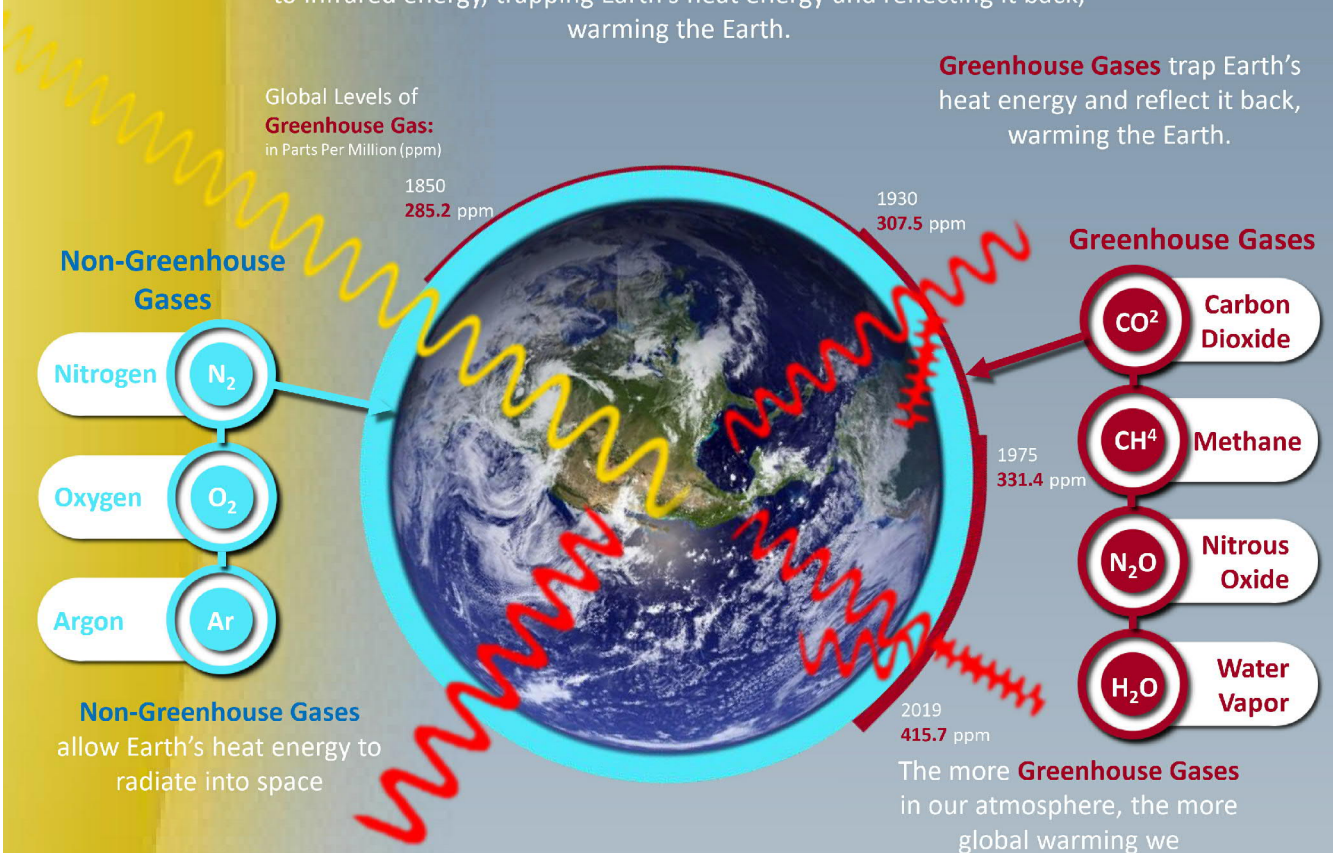
The Greenhouse Effect

Our atmosphere is made up of both **Non-Greenhouse** and **Greenhouse Gases**.

Non-Greenhouse Gases do not react to visible or infrared light, allowing both sunlight and infrared energy to pass unaffected. This mean's Earth's heat can radiate out into space.

Greenhouse Gases also do not react to visible light, however, they **DO** react to infrared energy, trapping Earth's heat energy and reflecting it back, warming the Earth.

Greenhouse Gases trap Earth's heat energy and reflect it back, warming the Earth.



Non-Greenhouse Gases allow Earth's heat energy to radiate into space

The more **Greenhouse Gases** in our atmosphere, the more global warming we experience.

Introduction

What is a Community Greenhouse Gas Inventory?

A community Greenhouse Gas (GHG) Inventory follows a standard protocol to quantify a city's greenhouse gas (GHG) emissions, including CO_2, CH_4, N_2O. GHG inventories fluctuate year-to-year as we change our energy consumption, get access to better data, or gain new knowledge about how GHGs impact the atmosphere.

What Are GHG's?

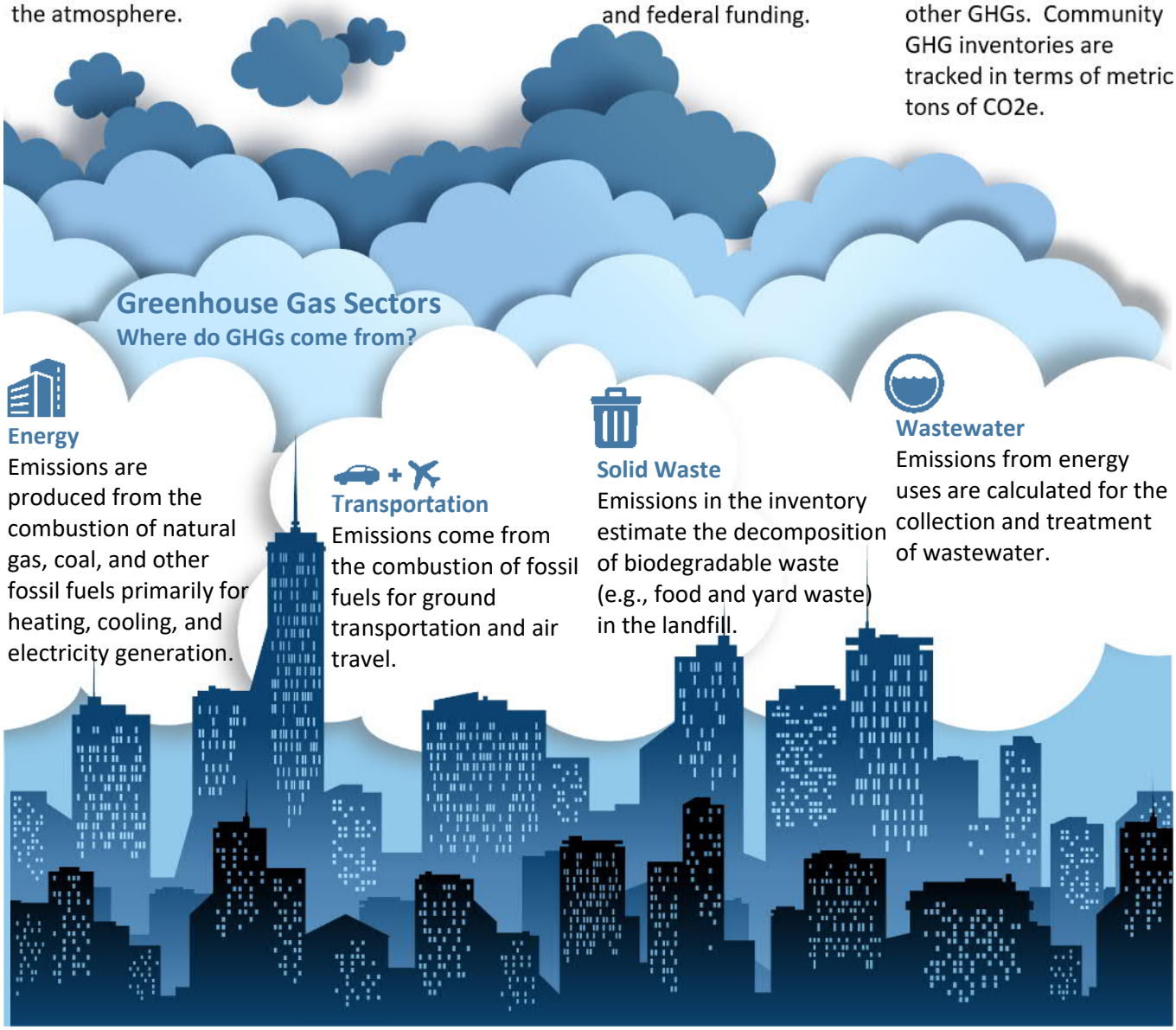
Greenhouse Gases (GHG) absorb radiation and trap heat in the Earth's atmosphere. They are the basis of the Greenhouse Effect. The more GHGs there are, the more heat that is trapped in our atmosphere, leading to Global Warming and Climate Change. GHGs measured in this inventory include carbon dioxide, methane, and nitrous oxide.

Why Measure GHG?

As described by David Osborne and Ted Gaebler "If you don't measure results, you can't tell success from failure. If you can't see success, you can't reward it. If you can't see failure, you can't correct it." GHG inventories are useful. Planners need them, elected officials want them, and the future may see their development as a basic requirement of state and federal funding.

What is CO2e?

Carbon Dioxide (CO_2) is a GHG emitted naturally and from fossil fuel combustion for energy and heat. Global warming contributions from other greenhouse gases are referred to in terms of "carbon dioxide equivalent" or CO_2e, which represents the amount of CO_2 that would have the same global warming potential as other GHGs. Community GHG inventories are tracked in terms of metric tons of CO_2e.



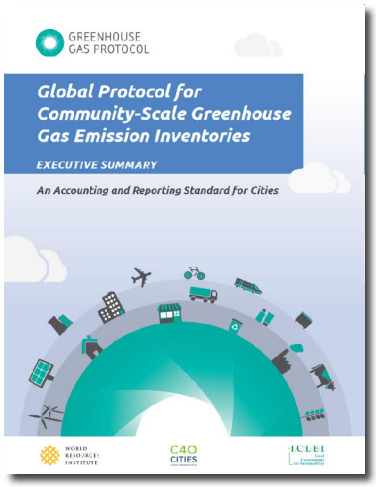
Introduction

Methodology, Sources, and Terminology

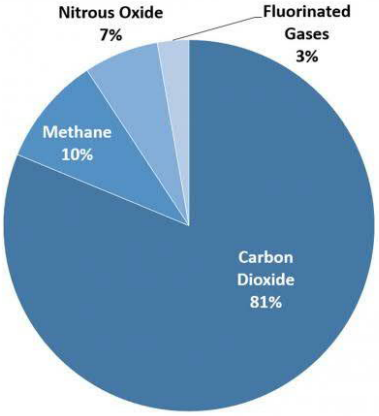
This GHG inventory is assembled based on the Greenhouse Gas Protocol for businesses and communities established by GHG Protocol (www.ghgprotocol.org/) and is consistent with the protocol established by ICLEI Local Governments for Sustainability. The terminology used in this report is consistent with international Carbon Footprinting protocols. Unless noted otherwise, the Greenhouse Gas (GHG) emissions shown in this report are in CO2e: Carbon Dioxide Equivalent. CO2e is a standard for expressing the impact of all greenhouse gas including those from other pollutants including methane (CH4), nitrous oxide (N2O), and florinated gasses like CFCs in terms of the equivalent amount of CO2 that would have the same impact. GHG emissions are represented in Metric Tonnes (2,204.62 pounds) to be consistent with international standard reporting.

GHG inventories, generally, arrive at an estimated emission in each emissions sector by multiplying raw consumption data - total electricity consumed as an example - by an emissions factor which define the greenhouse gasses emitted per unit of raw consumption. The chart below illustrates the sources used for all raw consumption and emission factor data used in the GHG inventory calculations.

The GHG emissions included in this inventory are those associated with sources and uses within the city of Chattanooga limits. To achieve that for electrical emissions, raw consumption data has been estimated by taking the known total electrical consumption within EBP's total service territory and reducing it on a pro-rata share based on EBP's estimated ratio of in-city premises client/consumption to out-of-city premises.



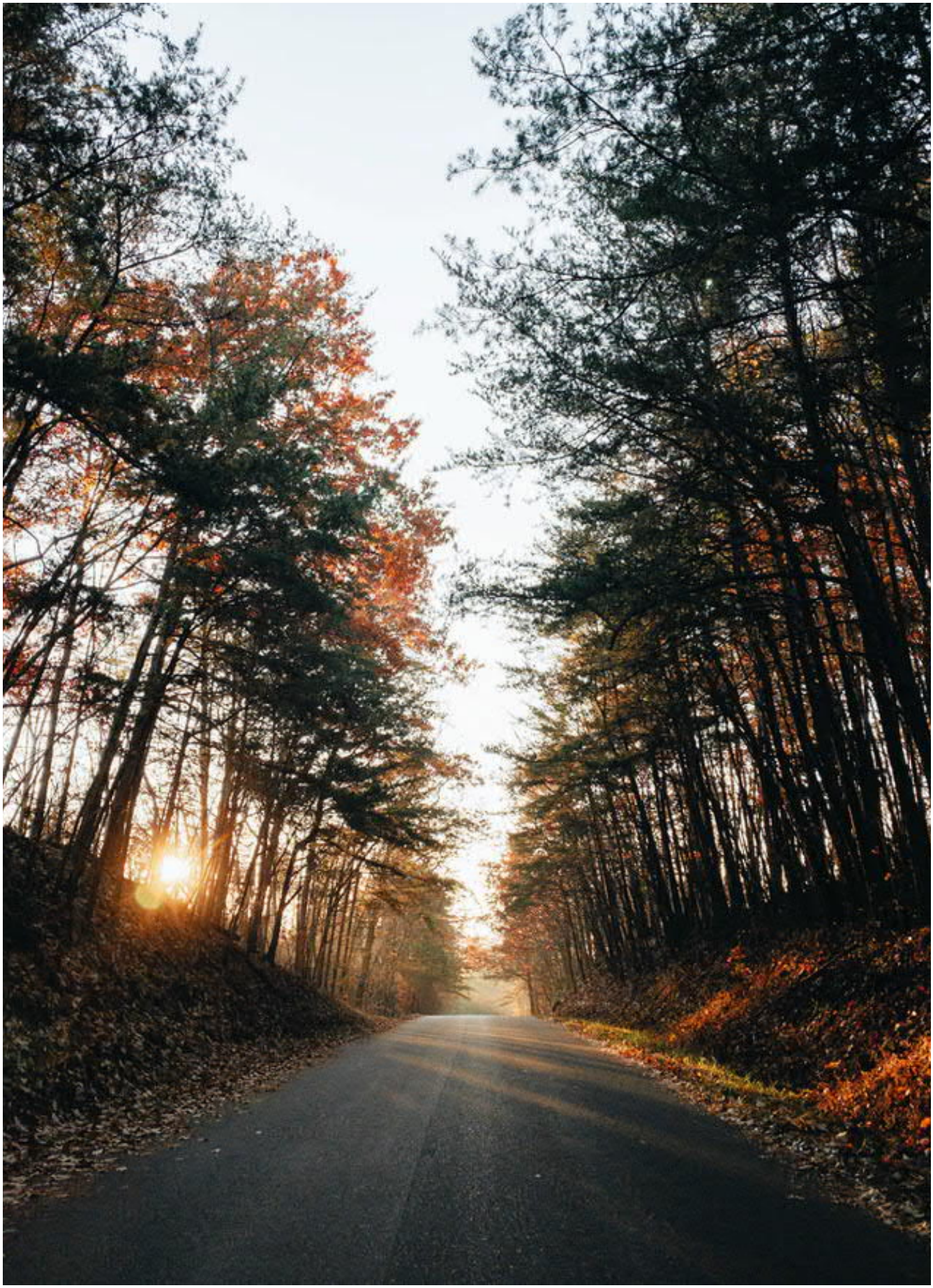
Overview of U.S. GHG Emissions by Greenhouse Gas Type



Source: U.S. EPA

Data Sources Used in the Greenhouse Gas Inventory

GHG Emission Sector	Project Resource
Residential Energy Consumption - Electricity	Data Source: EBP
	Emissions Factors: Same as above
Residential Energy Consumption - Natural Gas	Data Source: Chattanooga Gas / Southern Company
	Emissions Factors: US Community Protocol default fuel emission factors
Commercial/Institutional Energy Consumption - Electricity	Data Source: EBP
	Emissions Factors: Same as above
Commercial Energy Consumption - Natural Gas	Data Source: Chattanooga Gas / Southern Company
	Emissions Factors: US Community Protocol default fuel emission factors
Transportation - On Road	Thrive
	Emissions Factors: US EPA MOVES model
Waste - Solid Waste	Data Source: City of Chattanooga
	Emissions Factors: US Community Protocol Default Landfill Assumptions. RDF emissions factors.
Waste - Wastewater	Data Source: City of Chattanooga
	Emissions Factors: US Community Protocol population based emissions models / Fuel Mix Disclosure Report / US EPA eGRID
Water	Data Source: American Water
	Emissions Factors: Above emission factors for electricity and natural gas consumption.
Total road miles in City	State of Tennessee DOT



Section 02

Findings In Brief

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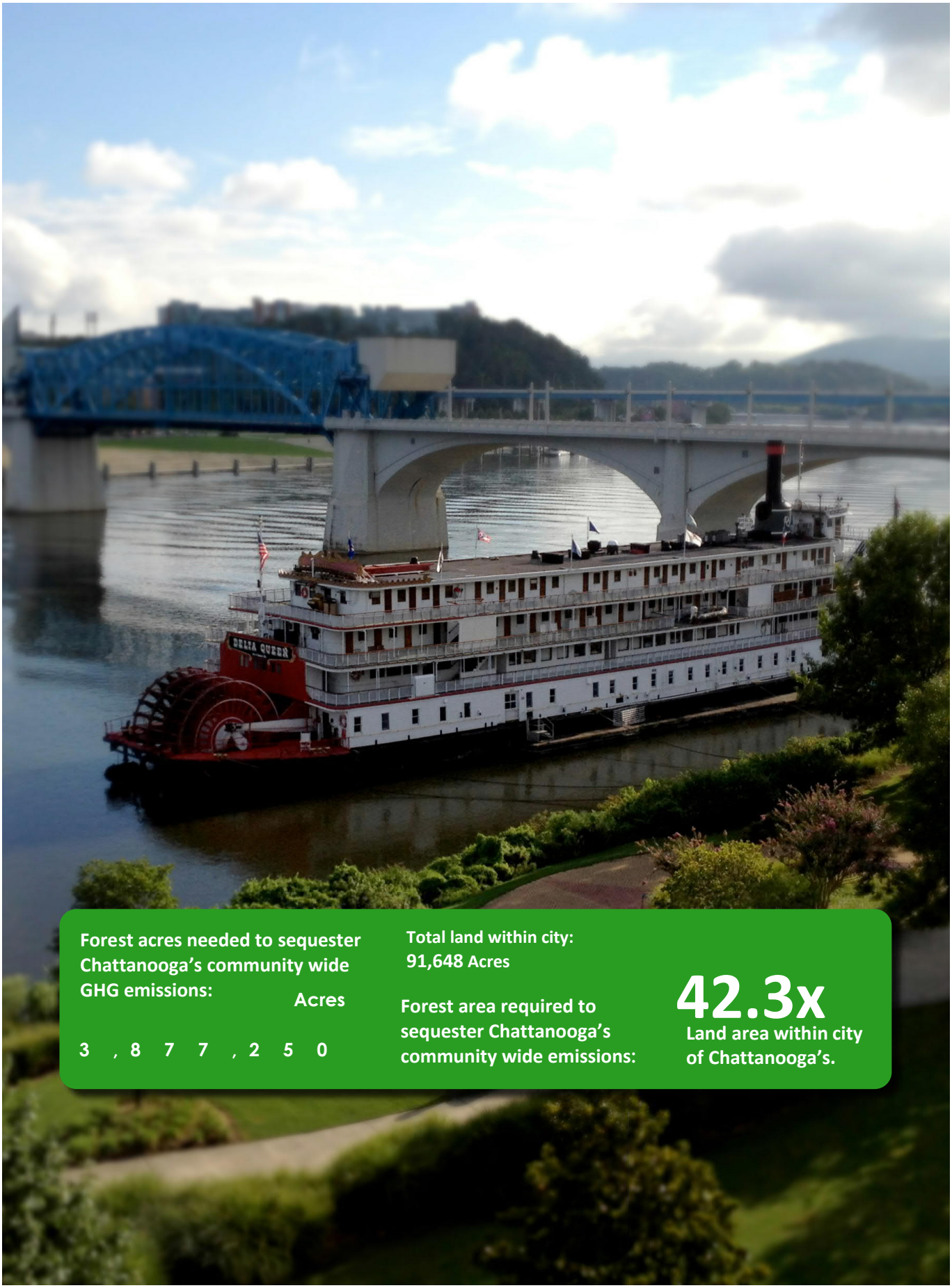


Forest acres needed to sequester Chattanooga's community wide GHG emissions:

3,877,250 Acres

Total land within city:
91,648 Acres

Forest area required to sequester Chattanooga's community wide emissions:

42.3x
Land area within city of Chattanooga's.

Findings In Brief

2008 By The Numbers

GHG Emissions
3,990,893
25.27 MT Per-Capita
13.21 MT / Job
0.1866 MT / $1,000 GDP

Population
157,901

GDP
21,384,260,000
$135,428 GDP Per-Capita

Employment
161,359

2018 By The Numbers

GHG Emissions
2,985,483
16.54 MT Per-Capita
7.64 MT / Job
0.0964 MT / $1,000 GDP

Population
180,551

GDP
30,971,172,000
$171,537 GDP Per-Capita

Employment
176,822

Ten-Year Trend Dashboard

GHG Emissions
-1,005,410 -25.19%
-8.74 MT Per-Capita
-5.57 MT / Job
-0.09 MT / $1,000 GDP

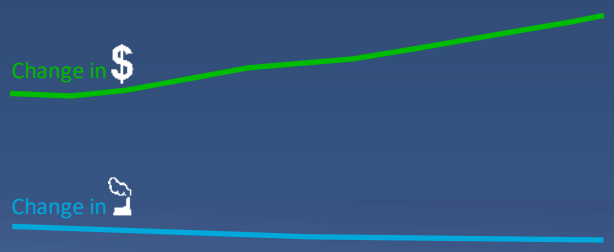
Population
+22,650 +14.34%

GDP
+$9,586,912,000
+$36,109 GDP Per-Capita

Employment
+15,463 +9.58%

Chattanooga Community Wide GHG Emissions Overview

Community wide total emissions for the city of Chattanooga dropped 25.19% from 3,990,893 metric tonnes in 2008 to 2,985,483 metric tonnes in 2018.

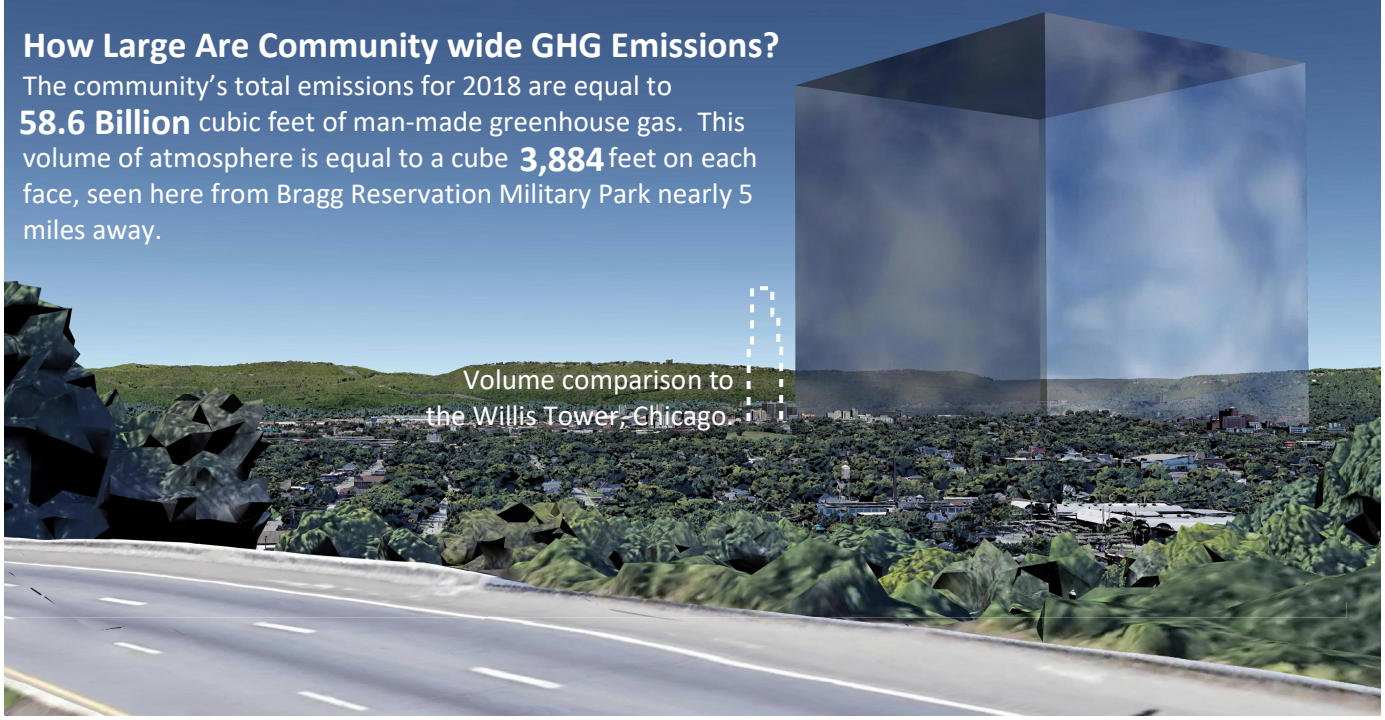


Think Economic Development is Tied To Increased Emissions?

Think again! Between 2008 and 2018 the city was able to decrease it's GHG emissions by 25.19% while growing it's economy by 44% and adding 9.58% more jobs!

How Large Are Community wide GHG Emissions?

The community's total emissions for 2018 are equal to **58.6 Billion** cubic feet of man-made greenhouse gas. This volume of atmosphere is equal to a cube **3,884** feet on each face, seen here from Bragg Reservation Military Park nearly 5 miles away.



Per-capita emissions for electrical consumption have declined 50% since 2008 due to a decrease in per-capita consumption and a decrease in the local GHG emissions factors for electricity generation. Per-capita emissions for natural gas consumption decreased 19%, due to reduced consumption.*

Since 2008, vehicle miles traveled (VMT) increased by 12.9%, but the associated GHG emissions increased by only 8.7% due to more efficient vehicles and cleaner fuels.

Air transportation emissions are not included in this inventory due to lack of data.

Per-capita emissions from solid waste management have increased 8% since 2008. The increase in emissions are due to an increase in landfill tonnage handled from 56,227 tons in 2008 to 69,618 tons annually in 2018.

Per-household wastewater flows have increased approximately 33.7% since 2008. Over the same time, emissions associated with wastewater treatment have decreased 38.3% due to a reduction in Natural Gas and electricity consumption as well as a reduction in emissions factor for process energy.

*Electricity consumption numbers are based on actual total utility service territory consumption per sector with estimated pro-rata share of properties located within city boundaries.

Section 03

Community Comparison

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Community Comparison

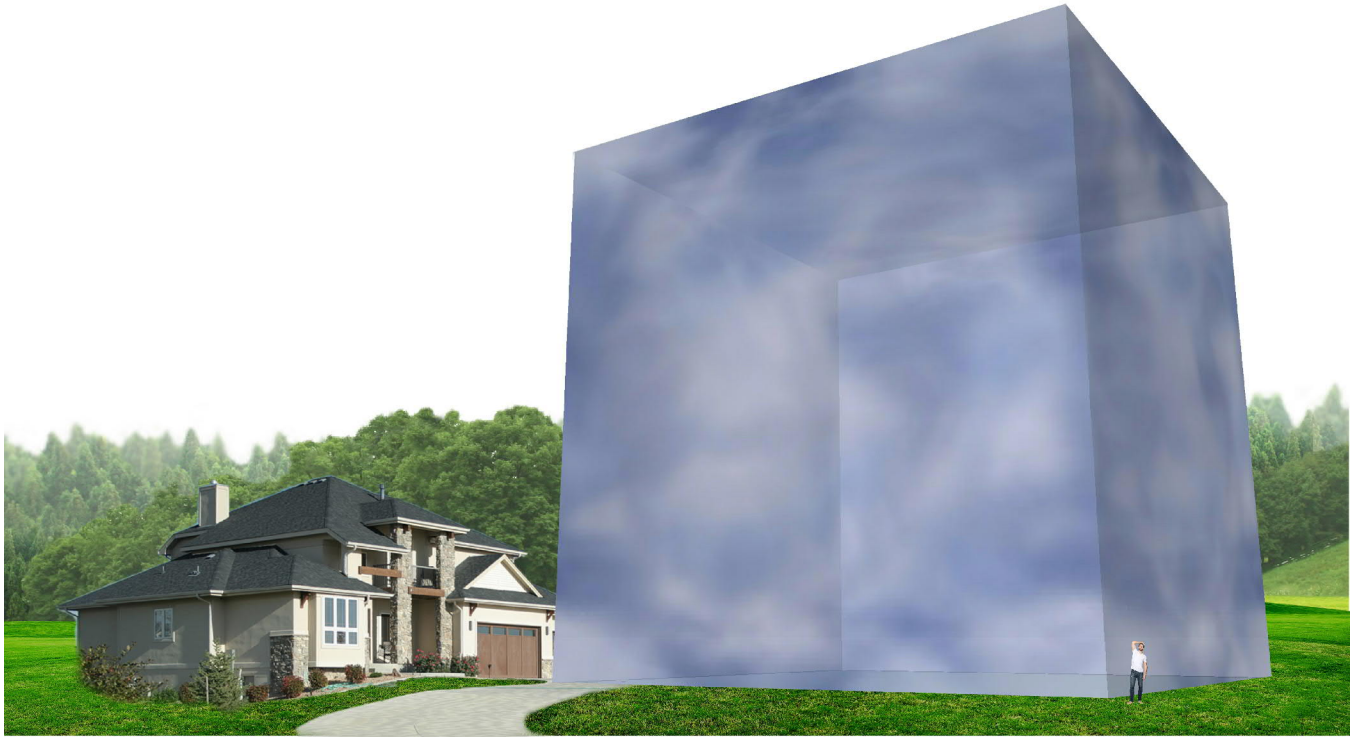
The results of community GHG inventories vary somewhat due to the information collected, variations in inventory methodology, community demographics, climate, economic factors, and regional considerations. Consequently, a direct community-to-community comparison should not be viewed as a comprehensive comparison of Greenhouse Gas emission efficiencies. We believe, however, that as an emerging practice, municipalities should look towards building and sharing data in order to develop a stronger understanding of where each municipality can advance efficiencies and meet Greenhouse Gas reduction goals. In support of this goal, comparing total community emissions between communities can only be effectively done by adjusting for differences in overall community population. To make this adjustment, community GHG emissions are regularly compared based on a per-capita basis.

Understanding Chattanooga' Per-Capita Community Wide Emissions

As outlined in Section 2, the city of Chattanooga' 2018 community wide emissions totaled 2,985,438 metric tons. By simply dividing this community wide emissions total by the total city population we arrive at an average of 16.54 metric tons (MT) per person. Of course, this number represents only an average. The actual emissions each individual resident may be responsible for generating can vary significantly based on a range of personal choices in energy and resource consumption and waste.

How Large Are Community Wide Per-Capita GHG Emissions?

The city of Chattanooga's community wide emissions per-captia for 2018 are equal to **324,443** cubic feet of man-made greenhouse gas. This volume of atmosphere is equal to a cube **68.7** feet on each face.



Community Comparison

Community Cohorts

In recognition of the varying influences which effect a community's greenhouse gas emissions, the city of Chattanooga community wide emissions are compared against a range of community cohorts, or peer groups: **Tennessee Communities**; **Regional Communities of Similar Size** with populations ranging from 100k - 300K; and **Other Regional Communities** with a range of population sizes offering.

Tennessee Communities

	Metric Tonnes (Thousands)	Per-Capita	Chattanooga Comparison
Knoxville:	3,999.9 TMT	21.71 MT	▲
Memphis:	17,192 TMT	26.32 MT	▲
Nashville:	12,276 TMT	18.08 MT	▲
Statewide Average:		14.59 MT	▼
Chattanooga:	2,985.5 TMT	16.54 MT	

Chattanooga's Percentile Among Tennessee Communities Compared: **25th**

Average Per-Capita Community Wide Emissions

State of Tenn Average:	15.59
Average of All Compared:	16.53
National Average:	16.94
Chattanooga:	16.54

Regional Communities of Similar Size

	Metric Tonnes (Thousands)	Per-Capita	Chattanooga Comparison
Richmond, VA:	3,152.5 TMT	14.47 MT	
Arlington, VA:	2,480.7 TMT	11.25 MT	▼
Columbia MO:	2,421.4 TMT	20.42 MT	▲
Des Moines, IA:	2,490.5 TMT	11.45 MT	▼
Durham, NC:	4,530.5 TMT	18.06 MT	▲
Knoxville, TN:	3,999.9 TMT	21.71 MT	▲
Lincoln, NE:	4,700.5 TMT	16.51 MT	▼
Savannah, GA:	3,609.5 TMT	25.0 MT	▲
Sioux Falls SD:	1,878.9 TMT	12.4 MT	▼
St Petersburg, FL:	2,693.2TMT	10.38 MT	▼
Average: (population weighted)		15.62 MT	▼
Chattanooga:	2,985.5 TMT	16.54 MT	

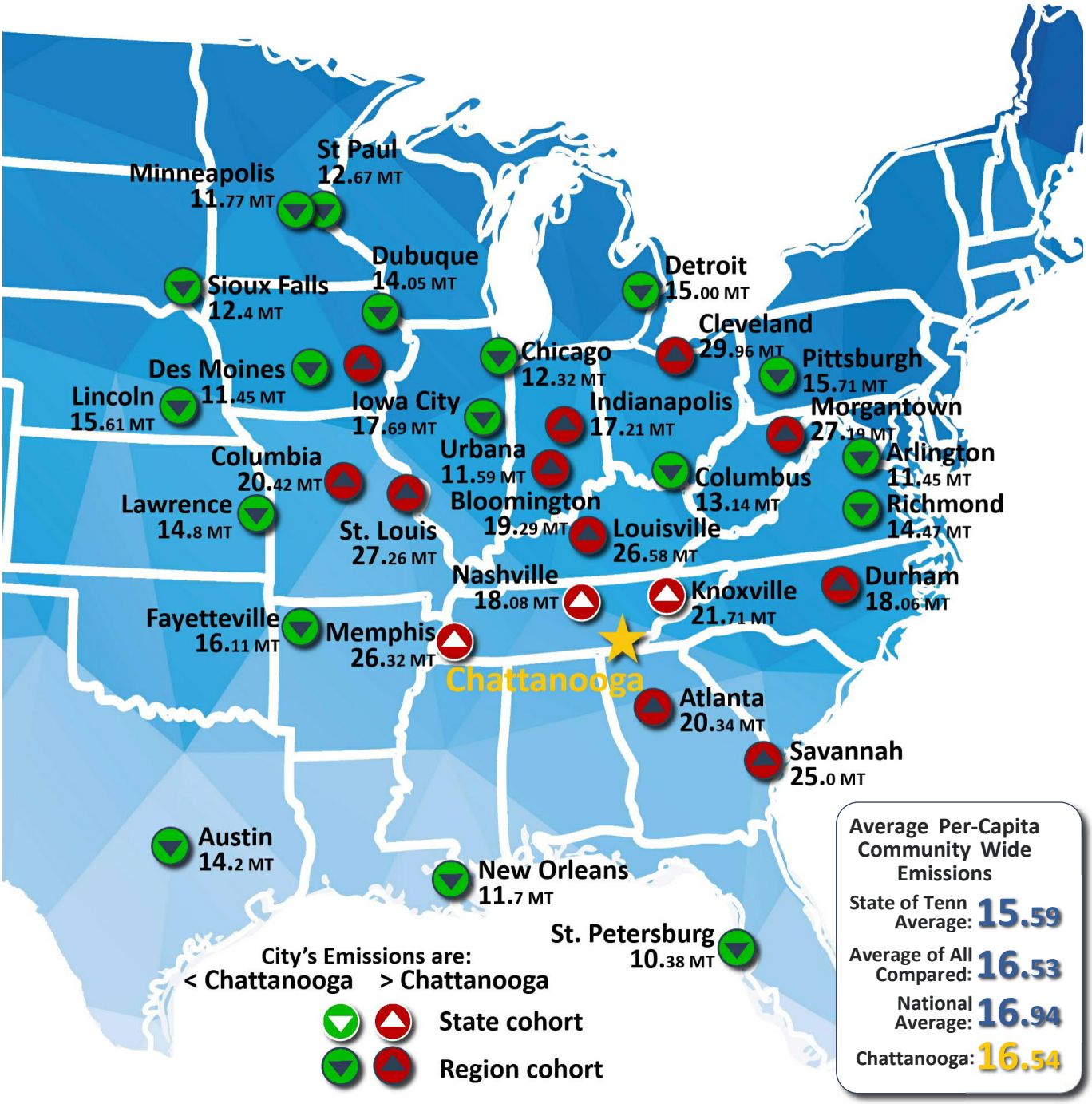
Chattanooga's Percentile Among Regional Communities of Similar Size: **64th**

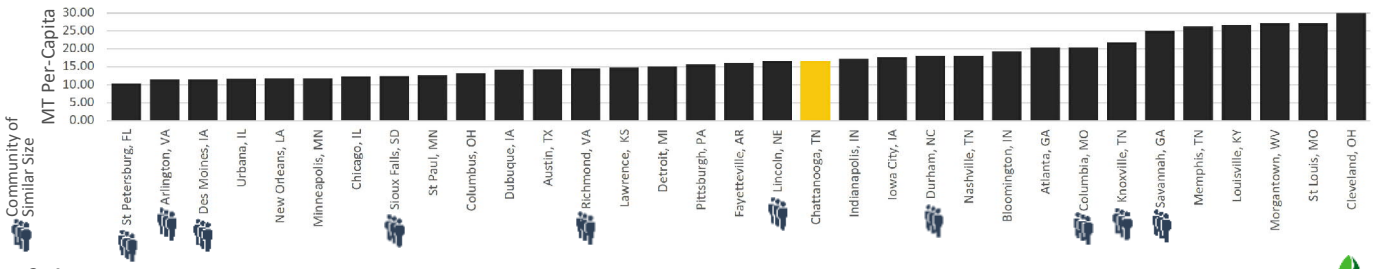
Other Regional Communities

	Metric Tonnes (Thousands)	Per-Capita	Chattanooga Comparison
Atlanta, GA:	9,024 TMT	20.34 MT	▲
Austin, TX:	13,500 TMT	14.20 MT	▼
Bloomington, IN:	1,639 TMT	19.29 MT	▲
Chicago, IL:	33,500 TMT	12.32 MT	▼
Cleveland, OH:	11,889 TMT	29.96 MT	▲
Columbus, OH:	10,983 TMT	13.14 MT	▼
Detroit, MI:	10,329 TMT	15.0 MT	▼
Dubuque, IA:	819 TMT	14.05 MT	▼
Fayetteville, AR:	1,379 TMT	16.11 MT	▼
Indianapolis, IN:	14,630 TMT	17.21 MT	▲
Iowa City, IA:	1,298 TMT	17.69 MT	▲
Lawrence, KS:	1,329 TMT	14.8 MT	▼
Louisville, KY:	16,000 TMT	26.58 MT	▲
Minneapolis, MN:	4,894 TMT	11.77 MT	▼
Morgantown, WV:	805 TMT	27.19 MT	▲
New Orleans, LA:	4,558 TMT	11.7 MT	▼
Pittsburgh, PA:	4,803 TMT	15.71 MT	▼
St Louis, MO:	8,703 TMT	27.26 MT	▲
St Paul, MN:	3,900 TMT	12.67 MT	▼
Urbana, IL:	487 TMT	11.59 MT	▼
Average: (population weighted)		16.2 MT	▼
Chattanooga:	2,985.5 TMT	16.54 MT	

Chattanooga's Percentile Among Other Regional Communities: **62nd**

Community Cohorts Map

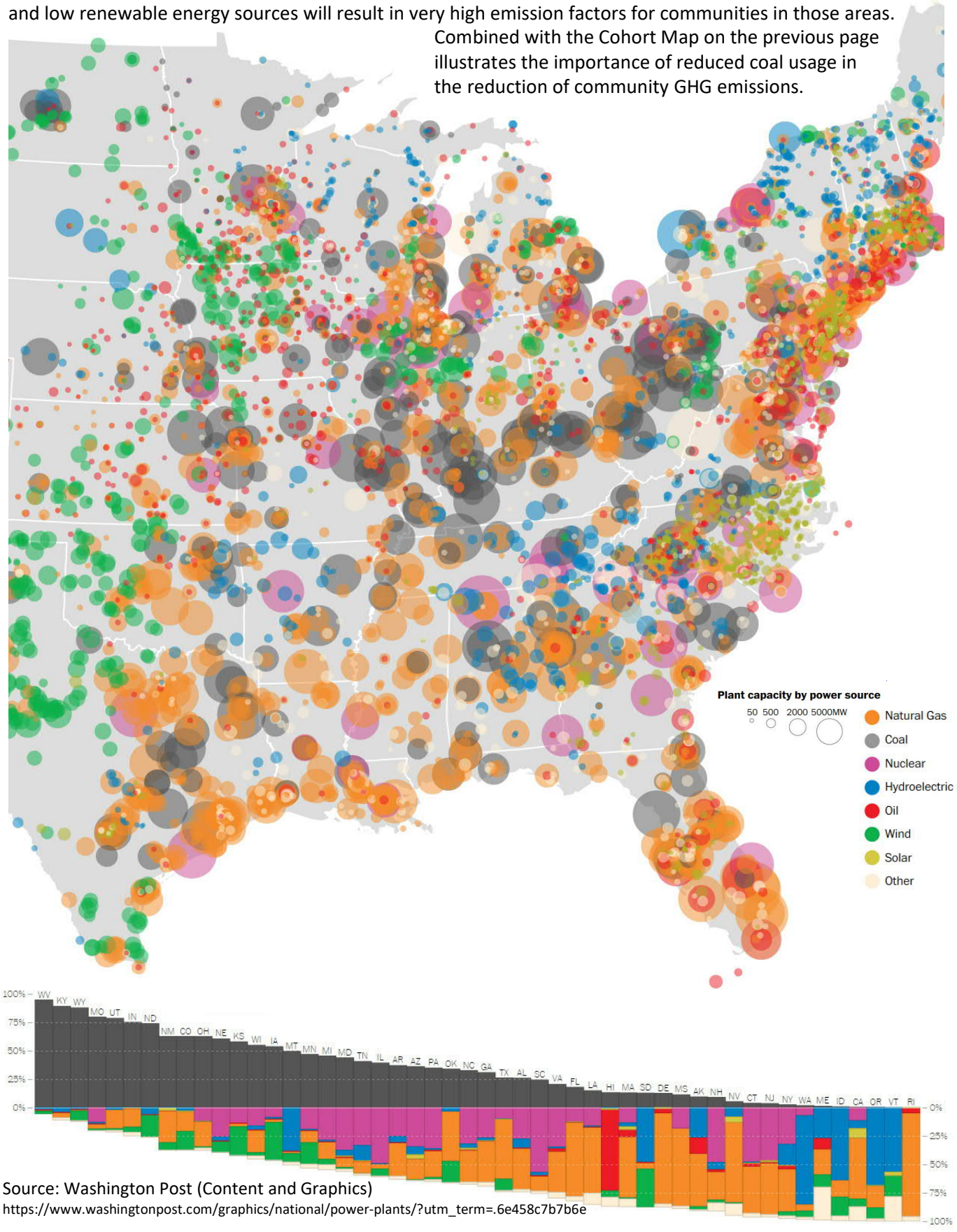




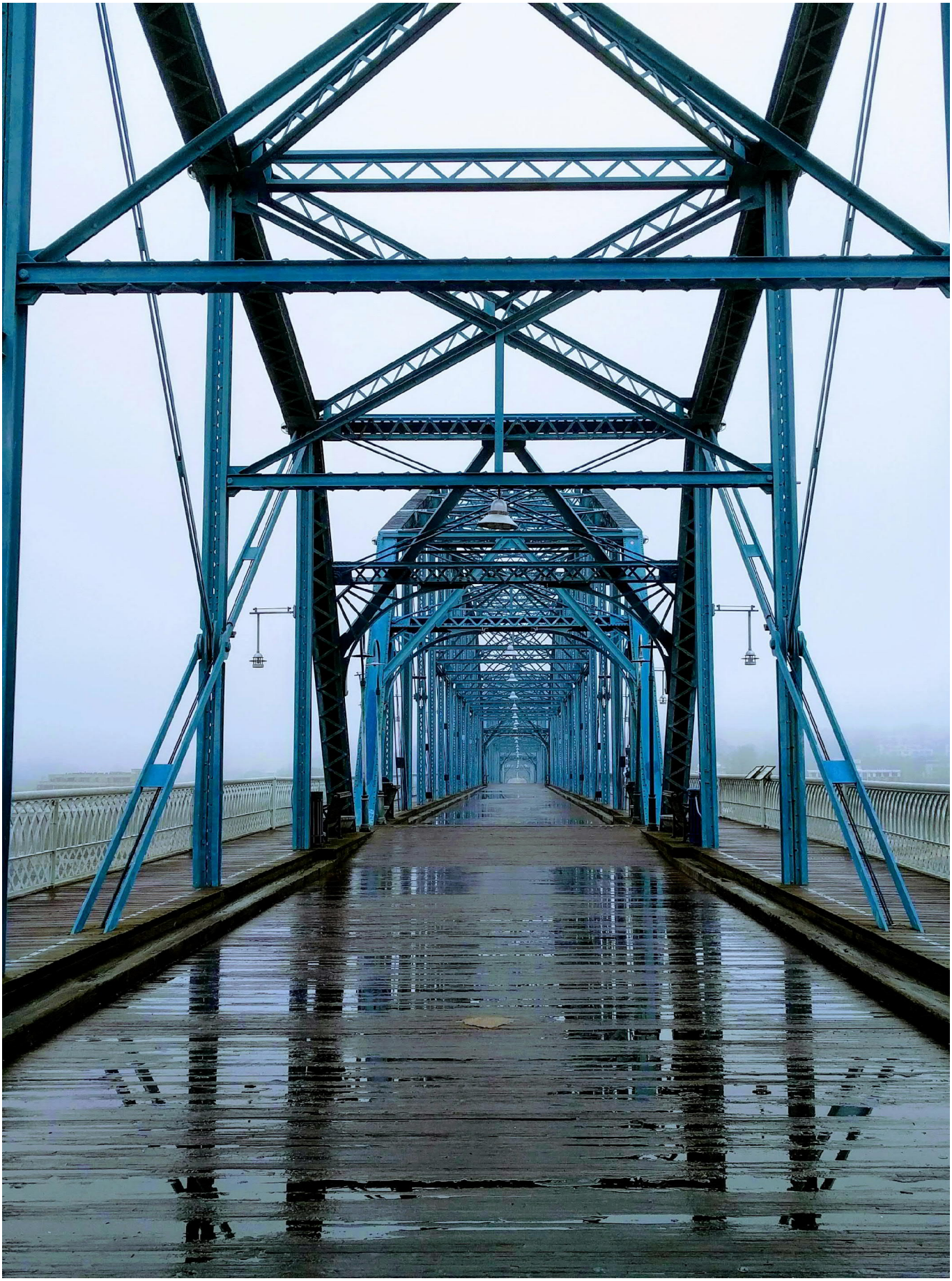
Community Comparison

United States Power Source Heat Map

The heat map below includes every power source in the eastern portion of the US. Instances of high coal power and low renewable energy sources will result in very high emission factors for communities in those areas. Combined with the Cohort Map on the previous page illustrates the importance of reduced coal usage in the reduction of community GHG emissions.



Source: Washington Post (Content and Graphics)
https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=.6e458c7b7b6e



Section 04

GHG Emissions Forecasting

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GHG Emissions Forecasting

Why Create a GHG Emission Forecast?

Increasing greenhouse gas emissions, and consequently, atmospheric concentrations, will have many effects on our global, regional, and local climate conditions. Future changes are expected to include a warmer atmosphere, a warmer and more acidic ocean, more powerful storms, broader swings in weather variability, and changes in precipitation patterns. The extent of future climate change depends our on-going GHG emissions. The more we emit, the broader our future climate changes will be. Put another way, the extent of climate change we experience in the future depends on the policies our communities put into place and the actions we as individuals take to reduce greenhouse gas emissions.

A GHG emission forecast supports GHG reduction planning efforts by anticipating what emissions may be like if actions are not taken. The potential future trends illustrated in the forecast supports planners in identifying emission sectors which may benefit from prioritization or which may harbor the greatest potential benefits for reduction strategies. Finally, the completed GHG emission forecast, combined with the underlying assumptions used to create the forecast model, can be used as a ***GHG reduction projection tool*** during future climate action planning efforts.

Business-As-Usual Forecast

Emissions are typically forecast under a business-as-usual (BAU) scenario. The Intergovernmental Panel on Climate Change (IPCC) defines a "business-as-usual" baseline case as the level of emissions that would result if future development trends follow those of the past and no changes in policies take place. A BAU forecast assumes that no emission-reduction actions will be undertaken beyond those already in place, or committed to, in the base year. The BAU forecast bases future projections on anticipated demographic changes, such as population changes and projected jobs within a community.

This approach allows for analysis of a community's full emissions growth potential before identifying emissions reduction strategies. As noted above, BAU emission forecasts are critical in providing insight into the scale of reductions necessary to achieve an emissions target before considering reductions likely to result from federal and statewide actions (e.g., vehicle efficiency standards), inherent technological advancements (e.g., energy-efficient appliances, lighting technology), or new local voluntary or mandatory conservation efforts (e.g., green building requirements).

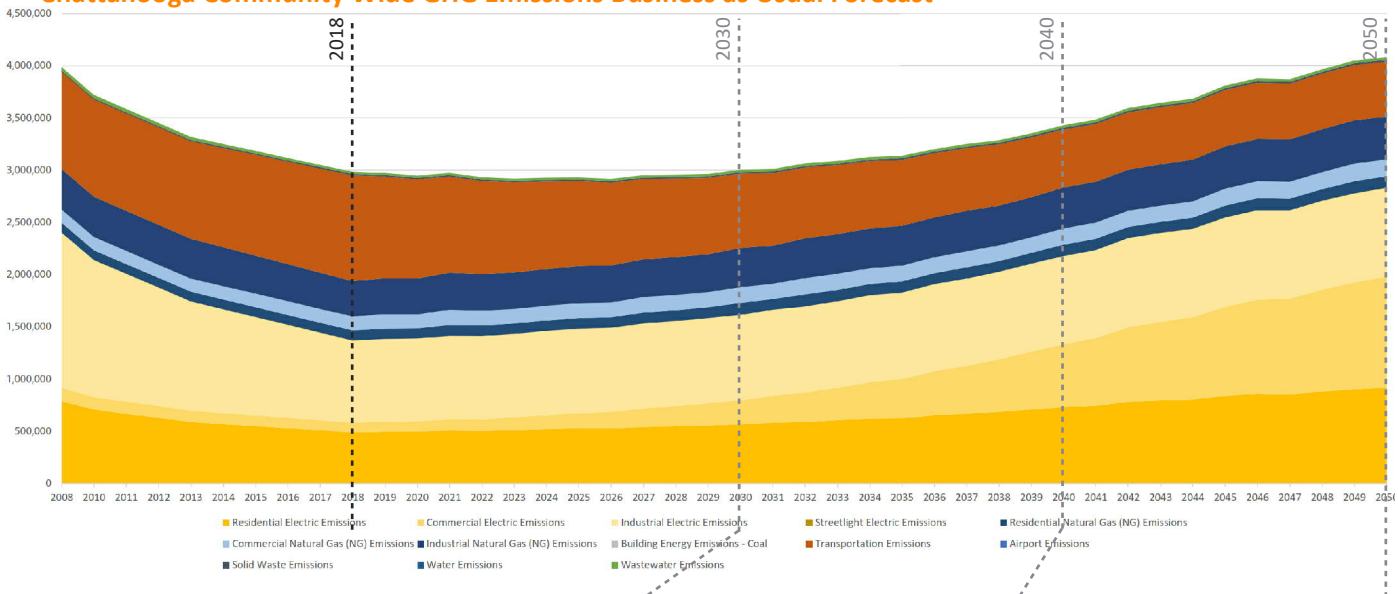
The city of Chattanooga community wide GHG forecasts included here were based on population and employment growth estimates projected based on community's share of Hamilton County projected growth as indicated in City's Comprehensive Plan. In addition to these data, information from Drive Electric Tennessee, the State of Tennessee Department of Economic and Community Development, the US Environmental Protection Agency, US Department of Transportation, and US Energy Information Agency. The full assumptions used for the Business-as-usual GHG Emissions Forecast model are outlined in detail in the appendix of this report.

Uncertainty

GHG emissions forecasts are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies. GHG forecasts in this report should be interpreted with a clear understanding of the assumptions that inform them and the limitations inherent in any modeling effort, as articulated in the forecast assumptions provided. The results of the forecast should be understood to contain uncertainty. Changes in industry structure over time, the particular impacts of policies, changing weather and economic conditions all add variability to how future emissions will develop.

GHG Emissions Forecasting

Chattanooga Community Wide GHG Emissions Business as Usual Forecast



2030 **3,005,212 MT**
-24.7%
From 2008 Baseline

Energy

Electricity Use: +10.4%
Residential - 1,560,597 MWH
Commercial - 242,352 MWH
Industrial - 2,319,283 MWH

Natural Gas Use: +4.5%
Residential - 21.1 MTherms
Commercial - 28.9 MTherms
Industrial - 70.8 Mtherms

Transportation

Ground: +23.5%
VMT - 2,165.6 MVMT

Airport: N/A

Solid Waste

Waste Handled: +119.4%
MSW - 185,780 Tons

Wastewater

Wastewater: -33.2%

2040 **3,431,047 MT**
-14.03%
From 2008 Baseline

Energy

Electricity Use: +33.4%
Residential - 2,123,192 MWH
Commercial - 671,205 MWH
Industrial - 2,525,363 MWH

Natural Gas Use: +7.2%
Residential - 20.3 MTherms
Commercial - 29.4 MTherms
Industrial - 74.1 Mtherms

Transportation

Ground: +32.7%
VMT - 2,328.0 MVMT

Airport: N/A

Solid Waste

Waste Handled: +136.1%
MSW - 199,916 Tons

Wastewater

Wastewater: -28.2%

2050 **4,083,474 MT**
+2.32%
From 2008 Baseline

Energy

Electricity Use: +70.0%
Residential - 2,828,773 MWH
Commercial - 1,250,972 MWH
Industrial - 2,698,408 MWH

Natural Gas Use: +11.3%
Residential - 20.8 MTherms
Commercial - 30.5 MTherms
Industrial - 77.4 MTherms

Transportation

Ground: +38.0%
VMT - 2,421.2 MVMT

Airport: N/A

Solid Waste

Waste Handled: +147.9%
MSW - 209,912 Tons

Wastewater

Wastewater: -24.6%

Section

A1

GHG Inventory Calculation Summary Spreadsheet

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Community Emissions Inventory Data Calculations

Emissions Sectors	Consumption, Energy, and Greenhouse Gas Emissions											MMBtu Change Since 2008	GHG Change Since 2008
	2008			2013			GHG Change from Prior	2018			GHG Change from Prior		
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			
Electricity[3] (Scope 2, MWh):													
Residential	1,286,860	4,390,765	785,499	1,236,658	4,219,477	587,629	-25.2%	1,283,197	4,378,269	488,799	-16.8%	-0.3%	-37.8%
Commercial and institutional	209,487	714,770	127,871	229,264	782,249	108,941	-14.8%	242,441	827,210	92,351	-15.2%	15.7%	-27.8%
Iindustrial (gross)	2,493,381	8,507,417	1,521,960	2,260,896	7,714,176	1,074,321	-29.4%	2,121,991	7,240,233	808,315	-24.8%	-14.9%	-46.9%
Reported Sector Process Subtractions													
Solid Waste, Water, Wastewater		(185,718)	(33,225)		(196,690)	(27,392)			(178,675)	(19,948)			
Iindustrial (Net)	2,493,381	8,321,699	1,488,735	2,260,896	7,517,486	1,046,929	-29.7%	2,121,991	7,061,558	788,367	-24.7%	-15.1%	-47.0%
Subtotals	**3,989,728**	**13,241,516**	**2,402,105**	**3,726,818**	**12,322,522**	**1,743,498**	**-27.4%**	**3,647,630**	**12,088,362**	**1,369,518**	**-21.5%**	**-8.7%**	**-43.0%**
Blended emission factor (tonnes per MWh)	0.610			0.475			-22.2%	0.381			-19.8%		-37.6%
Electricity as a % of total community amounts		35.4%	60.2%		33.9%	52.5%			33.1%	45.9%			
Natural gas (Scope 1, therms):													
Residential	17,673,464	1,766,924	93,647	17,520,411	1,751,622	92,836	-0.9%	18,031,438	1,802,713	95,544	2.9%	2.0%	2.0%
Commercial and institutional	24,151,971	2,414,620	127,975	23,412,599	2,340,700	124,057	-3.1%	25,483,258	2,547,717	135,029	8.8%	5.5%	5.5%
Iindustrial (gross)	73,707,929	7,369,031	390,559	72,669,640	7,265,227	385,057	-1.4%	63,811,115	6,379,586	338,118	-12.2%	-13.4%	-13.4%
Reported Sector Process Subtractions													
Solid Waste, Water, Wastewater		(35,259)	(1,869)		(38,216)	(2,025)			(32,012)	(1,697)			
Iindustrial (Net)	73,707,929	7,333,773	388,690	72,669,640	7,227,011	383,032	-1.5%	63,811,115	6,347,574	336,421	-12.2%	-13.4%	-13.4%
Subtotals	**115,533,364**	**11,480,058**	**610,312**	**113,602,650**	**11,281,118**	**599,925**	**-1.7%**	**107,325,810**	**10,665,991**	**566,994**	**-5.5%**	**-7.1%**	**-7.1%**
Emission factor (tonnes per MMBtu)	0.053			0.053				0.053					
Natural gas as a % of total community amounts		30.7%	15.3%		31.1%	18.1%			29.2%	19.0%			
Transportation (Scope 1):													
Vehicle miles traveled (thousands of miles)	1,753,888	12,421,001	932,137	1,782,608	12,478,409	934,414	0.2%	1,980,267	13,525,608	1,013,403	8.5%	8.9%	8.7%
Estimated Fuel Consumed	100,621,662			101,202,394			0.6%	109,698,811			8.4%		9.0%
Emission factor (tonnes per thousand VMT)	0.531			0.524			-1.4%	0.512			-2.4%		-3.7%
Airport	0	0	0	0	0	0	0.0%	0	0	0	0.0%	0.0%	0.0%
Subtotals		**12,421,001**	**932,137**		**12,478,409**	**934,414**	**0.2%**		**13,525,608**	**1,013,403**	**8.5%**	**8.9%**	**8.7%**
Emission factor	-			-				-					
Transportation as a % of total community amounts		33.2%	23.4%		34.4%	28.1%			37.1%	33.9%			
Solid Waste (Scope 1):													
Electricity (MWh)	-	-	-	-	-	-	0.0%	-	-	-	0.0%	0.0%	0.0%
Natural gas (therms)	-	-	-	-	-	-	0.0%	-	-	-	0.0%	0.0%	
Solid Waste Handled	84,661			92,958			9.8%	171,645			84.6%		102.7%
Recycled (tons)	28,434		-	31,221		-	9.8%	102,027		-	0.0%		258.8%
Hazardous Material (tons)	-		-	-		-	0.0%	-		-	0.0%		0.0%
MSW managed as RDF (tons)	-		-	-		-	0.0%	-		-	0.0%		0.0%
Landfill (tons)	56,227		11,245	61,737		12,347	9.8%	69,618		13,924	12.8%		23.8%
Subtotals		**-**	**11,245**		**-**	**12,347**	**9.8%**		**-**	**13,924**	**12.8%**	**0.0%**	**23.8%**
Emission factor - RDF (tonnes per ton)	1.27			1.27				1.27					
Emission factor - Landfill (tonnes per ton)	0.20			0.20				0.20					
Solid waste as a % of total community amounts		0.0%	0.3%		0.0%	0.4%			0.0%	0.5%			
Wastewater (Scope 1):													
Wastewater Flows (gallons)	22,630,000,000			29,583,150,000			30.7%	30,260,340,000			2.3%		33.7%
Electricity (MWh)	54,431	185,718	33,225	57,647	196,690	27,392	-17.6%	52,367	178,675	19,948	-27.2%	-3.8%	-40.0%
Natural gas (therms)	352,670	35,259	1,869	382,250	38,216	2,025	8.4%	320,200	32,012	1,697	-16.2%	-9.2%	-9.2%
Diesel (gal.)	0	0	0	0	0	0	0.0%	0	0	0	0.0%		0.0%
Emissions from combustion of digester gas (tonnes)			0			0	0%			0	0.0%		0.0%
Subtotals		**220,977**	**35,093**		**234,906**	**29,418**	**-16%**		**210,688**	**21,644**	**-26%**	**-4.7%**	**-38.3%**
Wastewater as a % of total community amounts		0.6%	0.9%		0.6%	0.9%			0.6%	0.7%			
Community Totals (Scope 1 & 2):		37,363,551	3,990,893		36,316,956	3,319,602	-16.8%		36,490,649	2,985,483	-10.1%	-2.3%	-25.2%

Notes:

1 Electricity in MWh, natural gas in therms. Carbon dioxide equivalents (GHG) are expressed in metric tonnes, which equal 1,000 kilograms, 2,204.6 pounds, or 1.102 US tons.

2 To avoid double-counting, energy consumption and emissions associated with process electricity and process natural gas for wastewater treatment and solid waste management are subtracted Electricity and Natural Gas sectors

3 Electricity consumption numbers are based on actual total utility service territory consumption per sector with estimated pro-rata share of properties located within city boundaries.

Section

A2

GHG Forecast Assumptions

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GHG Forecast Assumptions

Demographics:

- **Population:** Total Population projections through 2040 are projected based on community's share of Hamilton County projected growth as indicated in City's Comprehensive Plan (approximately 10% growth in 10 years). Projections through 2050 anticipate a reduction of growth rate to 5% in 10 years.

- **Households:** Total household counts are based on maintaining 2018 household to population ratios.

- **Jobs:** Total commercial and industrial jobs are calculated based on maintaining the existing 2018 jobs-per-population ratio.

Climate Data

- **Cooling Degree Days (CCD):** Projected climate changes for the region will include increased summer temperatures. The increase in temperatures will result in an increase, or variability, in air conditioning demand. The forecast calculates annual changes in air conditioning demand based on projections provided by the "Climate Explorer" tool developed by US NOAA in support of the National Climate Assessment work. https://crt-climate-explorer.nemac.org/

- **Heating Degree Days (HDD):** Projected climate changes for the region will include increased winter temperatures. The increase in temperatures will result in a decrease, or variability, in building heating demand. The forecast calculates annual changes in heating demand based on projections provided by the "Climate Explorer" tool developed by US NOAA in support of the National Climate Assessment work. https://crt-climate-explorer.nemac.org/

Electricity:

- **Residential:** Demand is based on a per household basis and modified based on the projected Cooling Degree Days for each year, assuming 15% of electricity is used for cooling (RCP 8.5 model). 50% of projected increased electrical vehicle usage is attributed to residential EV charging.

- **Commercial and Industrial**: Demand is based on a per job basis and modified based on projected cooling degree days for each year, assuming that 15% of commercial and 7.5% of industrial electricity is used for cooling. (RCP 8.5 model). 50% of projected increased electrical vehicle usage is attributed to commercial EV charging

- **All electricity emission factors** are calculated using estimated emissions factors for 2030, 2040, and 2050 based on current, known, supplier commitments. For electrical suppliers with unknown or unestablished emission commitments, and for electricity purchased from the SERC grid, electricity emission factors are calculated based on EPA forecasts (https://fas.org/sgp/crs/misc/R45453.pdf). Estimated emissions factors are reduced 5% by 2030, 10% by 2040, and 15% by 2050.

Natural Gas:

- Residential: Demand is based on a per household basis and modified based on the projected Heating Degree Days for each year, assuming 75% of natural gas is used for heating (RCP 8.5 model).

- Commercial and Industrial: Demand is based on a per job basis and modified based on projected heating degree days for each year, assuming that 40% of commercial and 20% of industrial natural gas is used for heating (RCP 8.5 model).

- Natural Gas emissions factors are projected to be unchanged.

GHG Forecast Assumptions

Transportation:

- Vehicle Miles Traveled is based on US Department of Transportation VMT per capita projections through 2050 (1.1% annual growth rate through 2037 and 0.8% annual growth rate from 2038 through 2050)https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.cfm

- Vehicle fuel use is calculated based on US Energy Information Agency projected rolling stock average fuel efficiency projections, modified to 75% projected MPG to account for heavy duty vehicle MPG share (based on US Department of Transportation data on current light duty to average all vehicle MPG ratios) https://www.eia.gov/todayinenergy/detail.php?id=31332

- Total vehicle stock is based on per household projections maintaining existing average number of vehicles per household through 2030 (2.556) and then reducing the average vehicle per household 10% through 2050 (2.3).

- Electric Vehicle Adoption: Transportation emissions assume a reduction in fossil fuel based VMT emissions based on estimated adoption rates. Adoption rates for 2030 are based on based on community's share of state projected total EV's from "A Roadmap for Electric Vehicles in Tennessee" by Drive Electric Tennessee. Adoption rates for 2040 and 2050 are based on a 1% annual increase from 2030 projections. Existing vehicle stock is assumed to be replaced based on an average replacement lifespan of 15 years. (https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.pdf https://berla.co/average-us-vehicle-lifespan/).

Solid Waste:

- Total Solid Waste handled is based on total number of households and maintaining existing volume per household and emissions factors per ton handled.

Wastewater:

- Total Wastewater handled is based on total number of households and maintaining existing volume per household and emissions factors per household.

Note:

GHG emissions forecasts are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies. GHG forecasts in this report should be interpreted with a clear understanding of the assumptions that inform them and the limitations inherent in any modeling effort.

Section

A3

Chattanooga Community Wide GHG Inventory - Infographic

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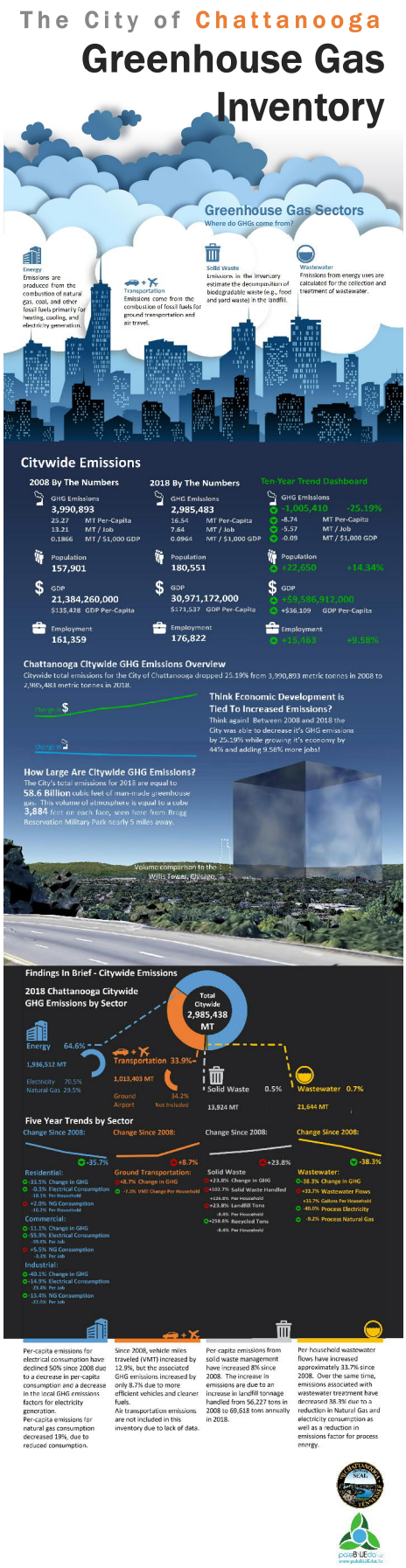

Chattanooga Community Wide GHG Inventory - Infographic

To the left is an image of the Chattanooga Community Wide Greenhouse Gas Inventory infographic created to summarize the findings of the inventory. Click on the image or scan the QR code to access the infographic.

https://palebluedot.llc/carbon-copy/2020/6/1/city-of-chattanooga-greenhouse-gas-inventory

Section

A4

GHG Inventory Glossary of Terms

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A

Activity Data
Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arisings are examples of activity data. (IPCC)

Aerosols
A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometer that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds. (IPCC2)

Afforestation
Planting of new forests on lands that historically have not contained forests. (IPCC2)

Air Pollutant
Any man-made and/or natural substance occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, and/or materials. (CARB)

Anthropogenic
The term "anthropogenic", in the context of greenhouse gas inventories, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities. (USEPA2)

Atmosphere
The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapor, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols. (IPCC2)

B

Baseline Emissions
A baseline is a measurement, calculation, or time used as a basis for comparison. Baseline emissions are the level of emissions that would occur without policy intervention or without implementation of a project. Baseline estimates are needed to determine the effectiveness of emission reduction programs (also called mitigation strategies).

Base Year
The starting year for the inventory. Targets for reducing GHG emissions are often defined in relation to the base year.

Biogenic
Produced by the biological processes of living organisms. Note that we use the term "biogenic" to refer only to recently produced (that is non-fossil) material of biological origin. IPCC guidelines recommend that peat be treated as a fossil carbon because it takes a long time to replace harvested peat.

Biogeochemical Cycle
Movements through the Earth system of key chemical constituents essential to life, such as carbon, nitrogen, oxygen, and phosphorus. (NASA)

Biomass
Either (1) the total mass of living organisms in a given area or of a given species usually expressed as dry weight; or (2) Organic matter consisting of or recently derived from living organisms (especially regarded as fuel) excluding peat. Includes products, by-products and waste derived from such material. (IPCC1)

Biomass Waste
Organic non-fossil material of biological origin that is a byproduct or a discarded product. "Biomass waste" includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural crop byproducts, straw, and other biomass solids, liquids, and gases; but excludes wood and wood-derived fuels (including black liquor), biofuels feedstock, biodiesel, and fuel ethanol. Note: EIA "biomass waste" data also include energy crops grown specifically for energy production, which would not normally constitute waste. (EIA)

Black Carbon
Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability; consists of soot, charcoal and/or possible light absorbing refractory organic matter (Charlson and Heintzenberg, 1995, p. 401). (IPCC2)

C

Carbon Cycle
All parts (reservoirs) and fluxes of carbon. The cycle is usually thought of as four main reservoirs of carbon interconnected by pathways of exchange. The reservoirs are the atmosphere, terrestrial biosphere (usually includes freshwater systems), oceans, and sediments (includes fossil fuels). The annual movements of carbon, the carbon exchanges between reservoirs, occur because of various chemical, physical, geological, and biological processes. The ocean contains the largest pool of carbon near the surface of the Earth, but most of that pool is not involved with rapid exchange with the atmosphere. (NASA)

Carbon Dioxide (CO_2)
A naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. (IPCC2)\

Carbon Dioxide Equivalent (CO_2e)
A metric used to compare emissions of various greenhouse gases. It is the mass of carbon dioxide that would produce the same estimated radiative forcing as a given mass of another greenhouse gas. Carbon dioxide equivalents are computed by multiplying the mass of the gas emitted by its global warming potential.

Carbon Disclosure Project (CDP)
An international organization that administers a platform for organizations and cities to publicly disclose their environmental impacts, such as climate risk. CDP is one of the approved disclosure platforms utilized by GCoM.

Carbon Emissions
The release of carbon dioxide into the atmosphere. Primary human sources of the release of carbon dioxide occur from burning oil, coal, and gas for energy use.

Carbon Equivalent (CE)
A metric measure used to compare the emissions of the different greenhouse gases based upon their global warming potential. Carbon equivalents can be calculated from to carbon dioxide equivalents by multiplying the carbon dioxide equivalents by 12/44 (the ratio of the molecular weight of carbon to that of carbon dioxide). The use of carbon equivalent is declining in GHG inventories.

Carbon Intensity
The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. (EIA)

Carbon Neutrality
For the purposes of the Plan, Carbon Neutrality refers to the point at which the organization / organization's net greenhouse gas emissions reach 0. This will likely be achieved through a combination of reducing emission sources and offsetting and sequestering any remaining emissions.

Carbon Sinks
A forest, ocean, or other natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere.

Carbon Sequestration
This refers to the capture of CO_2 from the atmosphere and its long term storage in oceans (oceanic carbon sequestration), in biomass and soils (terrestrial carbon sequestration) or in underground reservoirs (geologic carbon sequestration).

Chlorofluorocarbons (CFCs)
Greenhouse gases covered under the 1987 Montreal Protocol and used for refrigeration, air conditioning, packaging, insulation, solvents, or aerosol propellants. Because they are not destroyed in the lower atmosphere, CFCs drift into the upper atmosphere where, given suitable conditions, they break down ozone. These gases are being replaced by other compounds, including hydrochlorofluorocarbons and hydrofluorocarbons, which are greenhouse gases covered under the Kyoto Protocol. (IPCC3)

Circular Economy
An alternative to a traditional linear economy (make, use, dispose) in which an economy is a regenerative system where resource input and waste are minimized. This is achieved through long-lasting product design, repair, reuse, remanufacturing, and recycling. Circular economy strategies are often cited as systems level approaches to reducing waste generation through product and system design.

Climate
Climate in a narrow sense is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. (IPCC2)

Climate Adaptation or Resilience
The capacity of a natural environment to prevent, withstand, respond to, and recover from a disruption. The process of adjusting to new climate conditions in order to reduce risks to valued assets.

Climate Change
Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC2)

Climate Hazard
An extreme climate event or condition that can harm human health, livelihoods, or natural resources. It can include abrupt changes to the climate system such as extreme precipitation, storms, droughts, and heat waves.

Climate Vulnerability Assessment
A report used to identify and define the risks posed by climate change and inform adaptation measures needed to combat climate change. Reports can be about a wide range of fields including food security, poverty analysis, and extreme weather events.

Cogeneration
Cogeneration is an industrial structure, installation, plant, building, or self-generating facility that has sequential or simultaneous generation of multiple forms of useful energy (usually mechanical and thermal) in a single, integrated system. (CARB)

Combined Heat and Power (CHP)
Combined heat and power is the simultaneous production of both electricity and useful heat for application by the producer or to be sold to other users with the aim of better utilisation of the energy used. Public utilities may utilise part of the heat produced in power plants and sell it for public heating purposes. Industries as auto-producers may sell part of the excess electricity produced to other industries or to electric utilities. (IPCC)

Community Solar
Solar facilities shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced. Community solar allows members of a community to share the benefits of solar power on their property without installing it on their own property. Electricity generated by the community solar farm typically costs less than the price from utility companies.

Consistency
Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. (IPCC)

Continuous Emission Monitor (CEM)
A type of air emission monitoring system installed to operate continuously inside of a smokestack or other emission source. (CARB)

Criteria Air Pollutant
An air pollutant for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set. Examples include: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM10 and PM2.5. The term "criteria air pollutants" derives from the requirement that the U.S. EPA must describe the characteristics and potential health and welfare effects of these pollutants. The U.S. EPA and CARB periodically review new scientific data and may propose revisions to the standards as a result. (CARB)

D

Deforestation
Those practices or processes that result in the change of forested lands to non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present and contributing to carbon storage. (UNFCC)

Distillate Fuel Oil
A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation. (EIA)

E

Emissions
The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere. (USEPA1)

Emission Factor
A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions. (IPCC)

Emission Inventory
An estimate of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year. (CARB)

Emission Rate
The weight of a pollutant emitted per unit of time (e.g., tons / year). (CARB)

Environmental Justice
The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies

Estimation
Estimation is the assessment of the value of an unmeasurable quantity using available data and knowledge within stated computational formulas or mathematical models.

F

Fluorocarbons
Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine, or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). (UNFCC)

Flux
Either (1) Raw materials, such as limestone, dolomite, lime, and silica sand, which are used to reduce the heat or other energy requirements of thermal processing of minerals (such as the smelting of metals). Fluxes also may serve a dual function as a slagging agent. (2) The rate of flow of any liquid or gas, across a given area; the amount of this crossing a given area in a given time. (e.g., "Flux of CO2 absorbed by forests"). (IPCC)

Fossil Fuel
Geologic deposits of hydrocarbons from ancient biological origin, such as coal, petroleum and natural gas.

Fuel Combustion
Fuel combustion is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus. (IPCC)

Fugitive Emissions
Emissions that are not emitted through an intentional release through stack or vent. This can include leaks from industrial plant and pipelines. (IPCC)

G

Geologic Carbon Sequestration
It is the process of injecting CO_2 from a source, such as coal-fired electric generating power plant, through a well into the deep subsurface. With proper site selection and management, geologic sequestration could play a major role in reducing emissions of CO_2. Research efforts to evaluate the technical aspects of CO_2 geologic sequestration are underway. (USEPA4)

Global Warming
Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. Also see Climate Change (USEPA1)

Global Warming Potential (GWP)
An index, based upon radiative properties of well-mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing thermal infrared radiation. The Kyoto Protocol is based on GWPs from pulse emissions over a 100-year time frame. (IPCC2)

GCOM Global Covenant of Mayors:
GCoM is the largest global alliance for city climate leadership, built upon the commitment of over 10,000 cities and local governments. The alliance's mission is to mobilize and support climate and energy action in communities across the world.

Greenhouse Effect
Trapping and build-up of heat in the atmosphere (troposphere) near the earth's surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase. (UNFCC)

Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories:
A robust, transparent and globally-accepted framework that cities and local governments can use to consistently identify, calculate and report on city greenhouse gas emissions.

Greenhouse Gas
Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). (UNFCC)

Green Infrastructure
An approach to managing precipitation by reducing and treating stormwater at its source while delivering environmental, social, and economic benefits. Stormwater runoff can carry trash, bacteria, and other pollutants and is a major cause of water pollution in urban areas.

Gross Domestic Product (GDP)
The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. It is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources. (IPCC3)

H
Halocarbons
A collective term for the group of partially halogenated organic species, including the chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), halons, methyl chloride, methyl bromide, etc. Many of the halocarbons have large Global Warming Potentials. The chlorine and bromine-containing halocarbons are also involved in the depletion of the ozone layer. (IPCC2)

Hydrocarbons
Strictly defined as molecules containing only hydrogen and carbon. The term is often used more broadly to include any molecules in petroleum which also contains molecules with S, N, or O An unsaturated hydrocarbon is any hydrocarbon containing olefinic or aromatic structures. (IPCC)

Hydrofluorocarbons (HFCs)
Compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23). (USEPA1)

I
ICLEI Local Governments for Sustainability:
A membership organization for local governments to pursue reductions in carbon pollution and improvements in advancing sustainable urban development. ICLEI's members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

Intergovernmental Panel on Climate Change
The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories. (USEPA1)

K
Kilowatt Hour (kWh):
A measure of electrical energy equivalent to a power consumption of 1,000 watts for one hour.

Kyoto Protocol
The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol

(most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005. (IPCC2)

L

Land Use and Land Use Change
Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have a radiative forcing and/or other impacts on climate, locally or globally. (IPCC2)

LULUCF
Acronym for "Land Use, Land Use Change and Forestry", a category of activities in GHG inventories.

M

Megawatt Hour (MWH):
A measure of electrical energy equivalent to a power consumption of 1,000,000 watts for one hour.

Methane (CH_4)
A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO_2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, flooded rice fields, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Metric Ton
The tonne (t) or metric ton, sometimes referred to as a metric tonne, is an international unit of mass. A metric ton is equal to a Megagram (Mg), 1000 kilograms, 2204.6 pounds, or 1.1023 short tons.

Million Metric Tons (MMT)
Common measurement used in GHG inventories. It is equal to a Teragram (Tg).

Mitigation:
Actions taken to limit the magnitude or rate of long-term global warming and its related effects. Climate change mitigation generally involves reductions in human emissions of greenhouse gases.

Mobile Sources
Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes. (CARB)

Mode Share
The percentage of travelers using a particular type of transportation. Modal share is an important component in developing sustainable transport within a city or region because it reveals the level of utilization of various transportation methods. The percentage reflects how well infrastructure, policies, investments, and land-use patterns support different types of travel.

Model
A model is a quantitatively-based abstraction of a real-world situation which may simplify or neglect certain features to better focus on its more important elements. (IPCC)

Municipal Solid Waste (MSW)
Residential solid waste and some non-hazardous commercial, institutional, and industrial wastes. This material is generally sent to municipal landfills for disposal. (USEPA1)

N
Natural Sources
Non-manmade emission sources, including biological and geological sources, wildfires, and windblown dust. (CARB)

Net-zero Emissions (NZE)
Building A building or property that generates or offsets all energy consumed. If the City develops a NZE building code, this definition will have to be refined to provide additional guidance on calculating emissions and offsets to achieve net-zero emissions.

Nitrogen Fixation
Conversion of atmospheric nitrogen gas into forms useful to plants and other organisms by lightning, bacteria, and blue-green algae; it is part of the nitrogen cycle. (UNFCC)

Nitrogen Oxides (NO_x)
Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced in the emissions of vehicle exhausts and from power stations. In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), can impair visibility, and have health consequences; they are thus considered pollutants. (NASA)

Nitrous Oxide (N_2O)
A powerful greenhouse gas with a global warming potential of 298 times that of carbon dioxide (CO_2). Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, manure management, fossil fuel combustion, nitric acid production, and biomass burning. The GWP is from the IPCC's Fourth Assessment Report (AR4).

O
Ozone (O_3)
Ozone, the triatomic form of oxygen (O_3), is a gaseous atmospheric constituent. In the troposphere, it is created both naturally and by photochemical reactions involving gases resulting from human activities (smog). Tropospheric ozone acts as a greenhouse gas. In the stratosphere, it is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric ozone plays a dominant role in the stratospheric radiative balance. Its concentration is highest in the ozone layer. (IPCC2)

Ozone Depleting Substances (ODS)
A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone. (IPCC)

P
Perfluorocarbons (PFCs)
A group of human-made chemicals composed of carbon and fluorine only. These chemicals (predominantly CF_4 and

C_2F_6) were introduced as alternatives, along with hydrofluorocarbons, to the ozone depleting substances. In addition, PFCs are emitted as by-products of industrial processes and are also used in manufacturing. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases: CF_4 has a global warming potential (GWP) of 7,390 and C_2F_6 has a GWP of 12,200. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Photosynthesis
The process by which plants take carbon dioxide from the air (or bicarbonate in water) to build carbohydrates, releasing oxygen in the process. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations. (IPCC2)

Point Sources
Specific points of origin where pollutants are emitted into the atmosphere such as factory smokestacks. (CARB)

Power Purchase Agreement (PPA)
A power purchase agreement (PPA), or electricity power agreement, is a contract between two parties; one party generates electricity (the seller) and the other party looks to purchase electricity (the buyer). Individual customers and organizations may enter into PPAs with individual developers or may join together to seek better prices as a group. PPAs can allow longer term commitments to renewable energy as well as a form of “direct” investing in new renewable energy generation.

Property-Assessed Clean Energy (PACE)
A program created for financing energy efficiency and renewable improvements on private property. Private property can include residential, commercial or industrial properties. Improvements can include energy efficiency, renewable energy and water conservation upgrades to a building.

Process Emissions
Emissions from industrial processes involving chemical transformations other than combustion. (IPCC)

R
Radiative Forcing
A change in the balance between incoming solar radiation and outgoing infrared (i.e., thermal) radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases to the atmosphere traps an increased fraction of the infrared radiation, reradiating it back toward the surface of the Earth and thereby creates a warming influence. (UNFCC)

Reforestation
Planting of forests on lands that have previously contained forests but that have been converted to some other use. (IPCC2)

Regeneration
The act of renewing tree cover by establishing young trees, naturally or artificially - note regeneration usually maintains the same forest type and is done promptly after the previous stand or forest was removed. (CSU)

Renewable Energy
Energy resources that are naturally replenishing such as solar, wind, hydro and geothermal energy.

Renewable Energy Credits (RECs)
A market-based instrument that represents the property rights to the environmental, social and other non-power attributes of renewable electricity generation. RECs are issued when one megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource. The single largest category of

reductions in Evanston's emissions has been through the purchase of RECs.

Residence Time
Average time spent in a reservoir by an individual atom or molecule. Also, this term is used to define the age of a molecule when it leaves the reservoir. With respect to greenhouse gases, residence time usually refers to how long a particular molecule remains in the atmosphere. (UNFCC)

Reservoir
Either (1) a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored; or (2) Water bodies regulated for human activities (energy production, irrigation, navigation, recreation etc.) where substantial changes in water area due to water level regulation may occur. (IPCC)

Respiration
The process whereby living organisms convert organic matter to carbon dioxide, releasing energy and consuming molecular oxygen. (IPCC2)

Retro-commissioning
The systematic process to improve an existing building's performance ensuring the building controls are running efficiently and balancing the designed use and the actual use of the building.

Ride-share
The practice of sharing transportation in the form of carpooling or vanpooling. It is typically an arrangement made through a ride-matching service that connects drivers with riders.

S
Scope 1:
Scope 1 includes emissions being released within the city limits resulting from combustion of fossil fuels and from waste decomposition in the landfill and wastewater treatment plant.

Scope 2:
Scope 2 includes emissions produced outside the city that are induced by consumption of electrical energy within the city limits.

Scope 3:
Scope 3 includes emissions of potential policy relevance to local government operations that can be measured and reported but do not qualify as Scope 1 or 2. This includes, but is not limited to, outsourced operations and employee commute.

Short Ton
Common measurement for a ton in the United States. A short ton is equal to 2,000 lbs or 0.907 metric tons. (USEPA1)

Sink
Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere. (IPCC2)

Solar Radiation
Electromagnetic radiation emitted by the Sun. It is also referred to as shortwave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun, peaking in visible wavelengths. (IPCC2)

Source
Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere. (IPCC2)

Stationary Sources
Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit air pollutants. (CARB)

Sulfur Dioxide (SO_2)
A compound composed of one sulfur and two oxygen molecules. Sulfur dioxide emitted into the atmosphere through natural and anthropogenic processes is changed in a complex series of chemical reactions in the atmosphere to sulfate aerosols. These aerosols are believed to result in negative radiative forcing (i.e., tending to cool the Earth's surface) and do result in acid deposition (e.g., acid rain). (UNFCC)

Sulfur Hexafluoride (SF_6)
A colorless gas soluble in alcohol and ether, slightly soluble in water. A very powerful greenhouse gas with a global warming potential most recently estimated at 22,800 times that of carbon dioxide (CO_2). SF_6 is used primarily in electrical transmission and distribution systems and as a dielectric in electronics. This GWP is from the IPCC's Fourth Assessment Report (AR4).

T
Terrestrial Carbon Sequestration
It is the process through which carbon dioxide (CO_2) from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils. The term "sinks" is also used to refer to forests, croplands, and grazing lands, and their ability to sequester carbon. Agriculture and forestry activities can also release CO_2 to the atmosphere. Therefore, a carbon sink occurs when carbon sequestration is greater than carbon releases over some time period. (USEPA3)

Therm:
A unit of measure for energy that is equivalent to 100,000 British Thermal units, or roughly the energy in 100 cubic feet of natural gas. Often used for measuring natural gas usage for billing purposes.

Total Organic Gases (TOG)
Gaseous organic compounds, including reactive organic gases and the relatively unreactive organic gases such as methane. (CARB)

Transparency
Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information. (IPCC)

Trend
The trend of a quantity measures its change over a time period, with a positive trend value indicating growth in the quantity, and a negative value indicating a decrease. It is defined as the ratio of the change in the quantity over the time period, divided by the initial value of the quantity, and is usually expressed either as a percentage or a fraction. (IPCC)

U
Urban Tree Canopy
Describes the makeup and characteristics of trees within the urban environment.

V

VMT Vehicle Miles Traveled:
A unit used to measure vehicle travel made by private vehicles, including passenger vehicles, truck, vans and motorcycles. Each mile traveled is counted as one vehicle mile regardless of the number of persons in the vehicle.

W

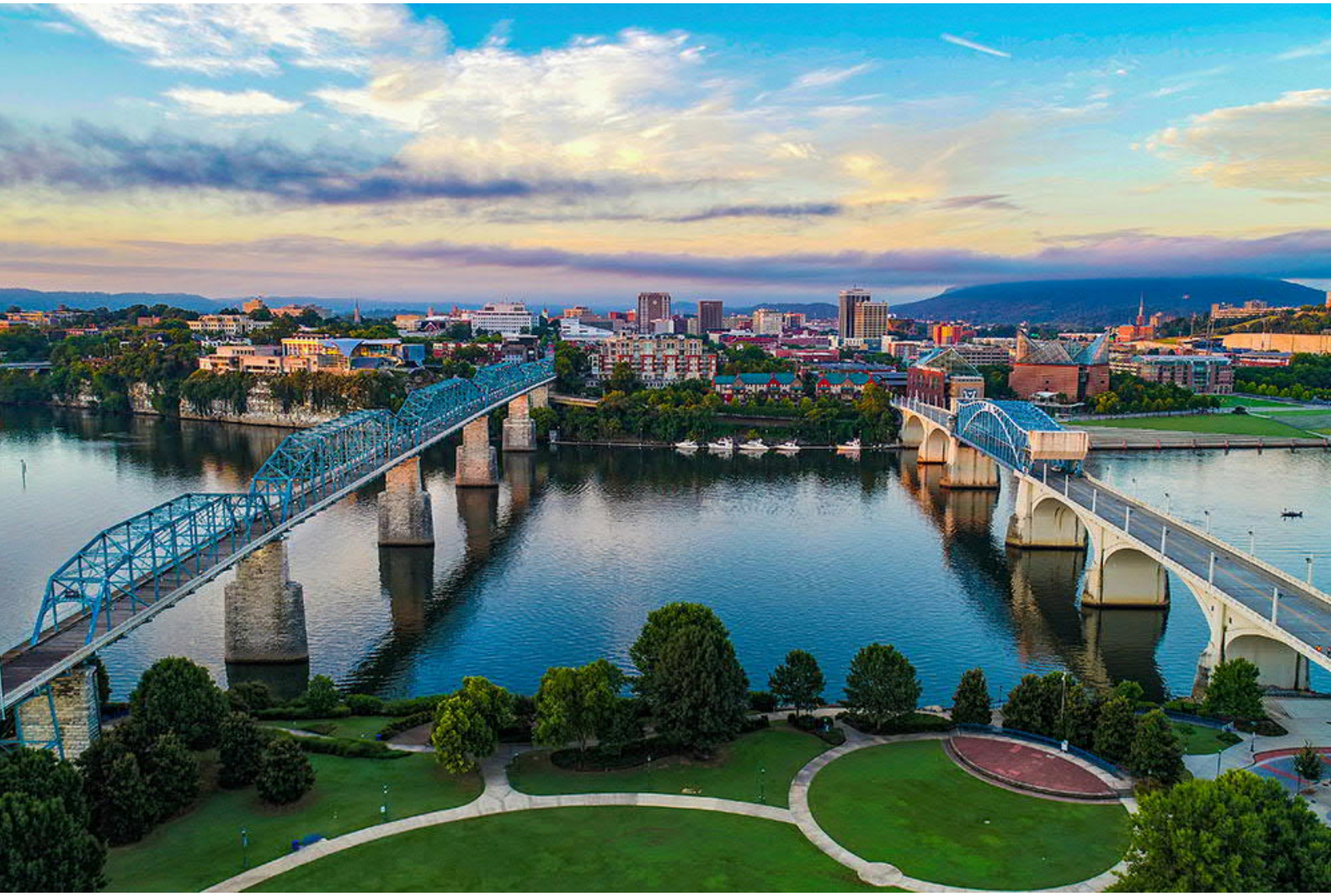
Water Vapor
The most abundant greenhouse gas; it is the water present in the atmosphere in gaseous form. Water vapor is an important part of the natural greenhouse effect. While humans are not significantly increasing its concentration, it contributes to the enhanced greenhouse effect because the warming influence of greenhouse gases leads to a positive water vapor feedback. In addition to its role as a natural greenhouse gas, water vapor plays an important role in regulating the temperature of the planet because clouds form when excess water vapor in the atmosphere condenses to form ice and water droplets and precipitation. (UNFCC)

Weather
Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard). (USEPA1)

Z

Zero Emission Vehicles (ZEV)
A vehicle that does not emit harmful emissions during operation. Harmful emissions can have a negative impact on human health and the environment. Electric (battery-powered) cars, electric trains, hydrogen-fueled vehicles, bicycles, and carriages are considered to produce zero emissions.

Zero Waste
A cyclical system in which products are designed for reuse, which creates no waste. A zero waste system eliminates the volume and toxicity of waste and materials and conserves current resources through reuse.



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