THE CITY OF NORFOLK

Mayor's Advisory Commission on Climate Change Mitigation and Adaptation

Climate Action Plan

May 2019

Table of Contents

Message from Co-Chairs 2

Executive Summary 4

Commission Members 10

Overview of Commission 15

Phase 1: Discovery 16

Phase 2: Setting Goals, Targets, Strategies 23

Phase 3: Recommendations - Goals 24

Renewable Energy Production: Increase usage of renewable energy 25

Buildings & Energy Use/Efficiency: Increase building and operation energy efficiency and reduce energy consumption 29

Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance 33

Consumption & Waste: First reduce, then reuse, then recycle 37

Food & Agriculture: Create and promote a sustainable food system 42

Engagement, Outreach, & Education: Environmental education and engagement 45

Appendix – ODU 2010 Draft Greenhouse Gas Inventory 48

May 2019

To Norfolk's Community,

As Co-Chairs of the Mayor's Advisory Commission on the Climate Change Mitigation and Adaptation "Commission," we would like to thank our Mayor and City Council Colleagues for establishing this Commission and their support of the region's first Climate Action Plan. Over the last year, we worked with Commission Members to develop this plan. We built off work already underway by our city, residents, businesses, higher education institutions, and non-profits to discuss, strategize, and plan how as a community we can work together to mitigate and to adapt to a changing climate.

The Commission focused on the reduction of greenhouse gas emissions to further position our city as a vibrant, resilient, healthy, and economically flourishing city. As we discussed goals, priorities, and performance measures, we highlighted why this is important: it is critical Norfolk be a leader in this conversation as our environment directly impacts our economy and our health. We discussed how behaviors and practices must change to support our children and grandchildren, the future of our city.

The Climate Action Plan includes strategies for the city to optimize its energy efficiency, to utilize clean renewable energy resources, and to review internal policies and practices. The Commission encouraged the municipal government to be a leader within our community. The plan presents an opportunity to innovate and to grow our economy through new industries such as offshore wind development. The Climate Action Plan is a plan for our entire community and includes strategies for our businesses, our schools, and our neighborhoods. We will work with our tremendous non-profits and advocacy groups to educate our community on how we can all be part of the solution. We challenge our residents to reduce their individual impact on the environment by limiting use of single-use plastics such as plastic bags and straws; biking or taking public transit to work; creating neighborhood gardens and cooperative composting; and, limiting energy use in our homes. We challenge our businesses to utilize clean energy sources; reduce waste and recycle; and, construct using sustainable, green building practices.

We would like to extend our gratitude to the Commission Members. This dedicated, diverse, and thoughtful group met consistently over the last year to develop strategies for our community. We learned a lot from each other during this process and the work occurring throughout our community to address our impact on the environment. We would also like to thank the City Manager for including an Environmental Services Manager within the city's budget who will review, implement, and monitor programs recommended by the Commission. We look forward to continuing this work as we move from planning to implementation.

Sincerely,

Andria McClellan Dr. Theresa Whibley

Page Intentionally Left Blank

Executive Summary

A Changing Global Climate

Recent climate reports from the United Nations Intergovernmental Panel on Climate Change (IPCC) and the U.S. Global Change Research Program (USGCRP) have analyzed the effects of the changing global climate and projected the potential impact if the increase in the global temperature is not mitigated. According to researchers from USGCRP, global climate is changing rapidly compared to natural variations in climate and global average temperature has increased by about 1.8°F from 1901 to 2016.[1] The evidence of climate change consistently points to human activities, the emission of greenhouse or heat-trapping gases as a dominant cause. USGCRP specially highlights the impacts to coastal cities, "Coastal communities and the ecosystems that support them are increasingly threatened by the impacts of climate change. Without significant reductions in global greenhouse gas emissions and regional adaptation measures, many coastal regions will be transformed by the latter part of this century, with impacts affecting other regions and sectors. Even in a future with lower greenhouse gas emissions, many communities are expected to suffer financial impacts as chronic high-tide flooding leads to higher costs and lower property values".[2] The USGRCP report identifies specific risks to the Southeast United States of high temperatures, flooding, and vector-borne disease.

Norfolk – A Coastal Community

Norfolk's history stems from its location as a Coastal City. Norfolk, Virginia is an independent city of nearly 247,000 residents and is 54 square miles. Norfolk is located with the Hampton Roads region of 1.7 million people. The city has remained and flourished as a globally important city due to one of Norfolk's greatest resources – 144 miles of shoreline along lakes, rivers, and the Chesapeake Bay.

Figure 1- Image from Hampton Roads Regional Benchmarking Study – 13th Edition – Hampton Roads Planning District Commission

Norfolk is a vital location for U.S. national security and economic prosperity. The city hosts Naval Station Norfolk, the largest naval base in the world, is home to the United States Fleet Forces Command and to the North Atlantic Treaty Organization (NATO) Allied Command Transformation, the only NATO command headquartered in North America. The city also hosts the Norfolk International Terminals, the Virginia Port Authority's largest terminals. Norfolk is the medical center of the Hampton Roads region and hosts the region's

[1] U.S. Global Change Research Program – Fourth National Climate Assessment - https://nca2018.globalchange.gov/chapter/2/
[2] U.S. Global Change Research Program – Fourth National Climate Assessment - https://nca2018.globalchange.gov/#sf-1

main trauma center for adults and pediatrics. Norfolk is the education center for the region with five institutions of higher education, Old Dominion University, Norfolk State University, Eastern Virginia Medical School, Tidewater Community College, and Virginia Wesleyan University. Norfolk is considered the arts and cultural center of the region.

Water gives shape and spirit to Norfolk. The city is home to beautiful rivers and creeks, beaches and the deepest natural port on the East Coast, all of which enable the city to thrive. Yet the water that supports our economy and recreation is also the one thing that presents one of the city's greatest challenges. After New Orleans, Norfolk has the largest population most at risk for land subsidence and sea level rise. Norfolk directly sees the impact of a changing climate first hand. The Virginia Institute of Marine Sciences (VIMS) provides data, education, and analysis on marine research. VIMS projects that by 2050 Norfolk at Sewells Point will see 1.32 feet of sea level rise.

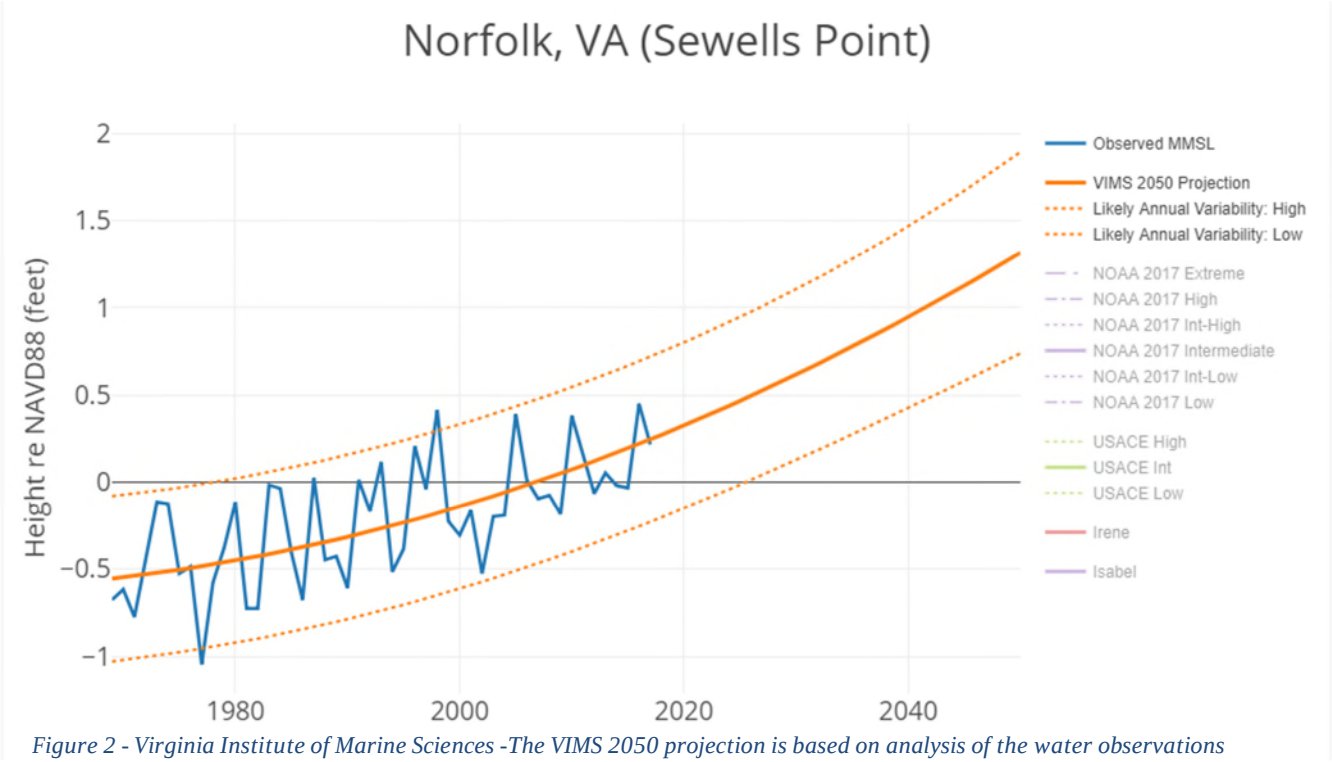


Figure 2 - Virginia Institute of Marine Sciences -The VIMS 2050 projection is based on analysis of the water observations over the past 40 years.

Mayor's Advisory Commission for Climate Change Mitigation and Adaptation

On June 1, 2017, Mayor Kenneth C. Alexander signed the Global Covenant of Mayors for Climate and Energy. By signing this commitment, the city agreed to establish a plan to address climate change mitigation and adaptation. To advise the city on a Climate Action Plan, City Council unanimously established the Mayor's Advisory Commission on Climate Change Mitigation and Adaptation (Commission) on January 23, 2018. The Commission is comprised of experts, advocates, residents, business and nonprofit leaders to help craft an implementation-focused roadmap to address Norfolk's changing climate. The Commission provides advice input concerning factors impacting climate and its

effect on citizens, specifically identifying goals, targets, and strategies to reduce greenhouse gas emissions.

The City of Norfolk has proactively been working to address its coastal and stormwater flooding challenges through its 100 Resilient Cities Strategy, Green Infrastructure Masterplan, U.S. Army Corps of Engineers Coastal Storm Risk Management Study, the National Disaster Resilience Competition Ohio Creek Watershed Project, and the city's resilient zoning code**. The Climate Action Plan will not address strategies related to flooding or green infrastructure since there are already strategies underway to address these critical areas.** The focus of the Climate Action Plan is to supplement the flooding mitigation and adaptation work with a focus on reducing greenhouse gas emissions.

The commission focused on targets and strategies within following goal areas in the plan:

- Renewable Energy Production: Increase usage of renewable energy
- Buildings & Energy Use/Efficiency: Increase building and operation energy efficiency and reduce energy consumption
- Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
- Consumption & Waste: First reduce, then reuse, then recycle
- Food & Agriculture: Create and promote a sustainable food system
- Engagement, Outreach, & Education: Environmental education and engagement

Summary of Strategies

The plan provides a variety of strategies for the overall Norfolk community to implement to reduce the greenhouse gas emissions. The Commission challenged the City of Norfolk (Municipal – Local Government) to be a leader within the community in reducing its carbon footprint. Municipal Operations made up just under 5 percent of total emissions within the overall city.[3] Top priority recommendations for the municipal government include the following:

- Expand and resource/staff within the city responsible for the implementation of Climate Action Plan goals and identification of grant resources and financing;

- Solar Survey - Inventory all municipal and school building rooftops for solar PV and hot water potential; Identify all municipal or authority open land for potential solar installation (i.e. Norfolk Airport); Identify all non-municipal government owned property for solar PV and hot water; Prioritize areas by locations in opportunity zones;

- PACE - Implement PACE (property assessed clean energy) funding mechanism to allow for financing of renewable energy by commercial, non-profit, multifamily properties;

[3] Old Dominion University Draft 2010 Greenhouse Gas Inventory Report for the City of Norfolk

- Sustainable Business Coalition - Create a recognition and incentive program for commercial purchases of green energy, to possibly include future tax incentives, procurement guidelines, and prioritization of municipal contracts from coalition members;

- City code and financing - Remove financial barriers to building retrofits, including limiting net property tax increases due to completed energy projects; Promote the use of alternative energy through supportive code changes to permit and require the use of new technologies, such as solar and wind power, while ensuring such technologies are compatible in established residential areas;

- City Appliances Policy - require all city-owned facilities to institute polices regarding turning off equipment and appliances.: e.g., Energy Star methodologies to have all computers, monitors, and printers go to sleep for nights/weekends/holidays;

- City Financed Projects - Enact a policy supporting City-financed projects (including performance grants for development) to meet an energy efficiency standard, such as LEED, Energy Star standards, National Home Builders Association (NHBA) Green Building, or Earthcraft; and

- Resilience Quotient – Review and update the Resilience Quotient for buildings in the 2018 Zoning Ordinance every three years (aligning with building codes updates) to reflect new energy efficiency and resilient best practices, which encourage green building.

In Virginia, local governments are limited to the powers expressly granted to them by the state. This is referred to as the Dillon Rule. Historically, the Commonwealth of Virginia has taken limited steps to address the changing climate and has not provided local governments with the authority to limit their overall cities carbon footprint. As an example, local governments in Virginia are not allowed to ban plastic bags or straws within their municipality unless the Virginia General Assembly specifically grants localities that power. Due to these limitations, many of the plan's recommendations focus on increased advocacy, education, incentive programs, and partnerships with businesses, non-profits and higher education to encourage the broader community to reduce its impact on the environment.

Top priority items for the broader community include the following:

- Workforce Development/Green Jobs - Create workforce development opportunities and credentialing for green jobs for Norfolk residents with a target to Norfolk Redevelopment and Housing communities;

- K-12 Sustainability Curriculum – Norfolk Public Schools and Private Schools to implement a sustainability curriculum for all K-12 schools, using existing lessons on how to audit your school/classroom for energy use, how to improve energy efficiency of your school, to proposing plans for alternative power including funding sources and for projects to improve carbon absorption through tree plantings etc. Students should develop annual projects to reduce the carbon footprint of their schools and homes;

- Reusable Bags and Single-Use Plastics - Support incentive programs that encourage the recycling of plastic bags, or programs that give a discount to consumers who bring their own reusable bag and support legislation at the Virginia General Assembly allowing local governments to regulate the distribution, sale or offer of disposable plastic bags and other single-use products such as straws and extruded polystyrene food and beverage containers;

- Sustainable Business Coalition – Encourage local businesses to cut their own carbon footprints by advertising the program and incentivizing creative methods of decreasing emission, as well as sharing lessons learned between members. Advertise and celebrate successful methods, such as ways to finance installation of solar and building efficiency incentives, such as Opportunity Zones Funds and C-PACE when it becomes available. Via the business coalition, encourage local businesses to take the same actions as Norfolk, such as setting A/C to reasonable values, enforcing no-idling and, transitioning to LED lights;

- Alternative Commute Incentives – Encourage businesses to incentivize lower-carbon alternatives to commuting, such as telecommuting, biking and walking;

- Expand No-Idling Policy – Challenge local businesses to implement and enforce the same no-idling policy for their vehicles as the city; and

- Residential Solar – Increase the residential solar deployed in Norfolk by 100 households per year for the next 10 years.

Page Intentionally Left Blank

Mayor's Advisory Commission on Climate Change Mitigation and Adaptation

Mayor
Kenneth C. Alexander

Co-Chairs
Ms. Andria McClellan, Councilmember, Superward 6
Dr. Theresa W. Whibley, M.D., Former Councilmember, Ward 2

Commission Members
Monique Adams, Citizen Member
Ray Amoruso, Hampton Roads Transit
Ruth McElroy Amundsen, Citizen Member
Kiquanda Baker, Chesapeake Climate Action Network
Michael Benedetto, TFC Recycling
Robert S. Bowen, Norfolk International Airport
Christopher "Kit" Chope, Virginia Port Authority
Joe W. Dillard, Jr., NAACP
Christy Everett, Chesapeake Bay Foundation
Christen T.S. Faatz, Developer
Rhonda Ingram, Norfolk Public Schools
Marjorie Jackson, Elizabeth River Project
James Kibler, Virginia Natural Gas
Eileen Levandoski, Sierra Club
Georgie Marquez, AIA, NCARB, Architect
Nathaniel McCormick, Norfolk Redevelopment and Housing Authority
Margaret R. Mulholland, Ph.D., Old Dominion University
William L. Murray, Dominion Energy
Ann Claire Phillips, US Navy RADM (ret), Citizen Member
Candace L. Reid, Hampton Roads Chamber of Commerce
John D. Stewart, Wetlands Watch
Stephen M. Via, Ph.D., Norfolk State University
Paul B. Wallace, Tidewater Builders Association
Audrey P. Webb, Norfolk Environmental Commission
Tom Werner, Norfolk Southern
David C. White, Virginia Maritime Association
Eric M. Young, Sentara

City of Norfolk Staff
Adisa Muse, Deputy City Clerk, City Clerk's Office
Morgan Whayland, City Manager's Office, Intergovernmental Relations Officer
Norah McDonald, City Manager's Office, Municipal Intern, MPP Candidate, University of Virginia

Thank you to all presenters and participants who provided invaluable information and support to the commission

Introduction

On June 1, 2017, Mayor Kenneth C. Alexander signed the Global Covenant of Mayors for Climate and Energy. The Global Covenant of Mayor's is a coalition created by the Compact of Mayors and the European Union Covenant of Mayors. The coalition is an international alliance of cities and local governments with a shared long-term vision to pursue the goals of the Paris Accord through promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society. The covenant is made up of 9,000 cities and local governments worldwide, "from six continents and 127 countries, representing 770 million residents"[1]. In the United States, 157 cities and counties are covenant members.

By signing the Global Covenant of Mayors for Climate Change and Energy, the City of Norfolk acknowledges its commitment to:

- conduct a community-wide greenhouse gas (GHG) inventory;
- establish targets to reduce emissions;
- detail climate change vulnerabilities faced by the city; and
- establish a plan to address climate change mitigation and adaptation.

To accomplish these tasks, the Mayor's Advisory Commission on Climate Change Mitigation and Adaptation was established on January 23, 2018 through City Council action. The commission assists the Mayor and Council in meeting the commitment of the Global Covenant and acts as an advisory on matters involving climate change mitigation and adaptation.

Key terms in this Climate Action Plan:

Mitigation: Limiting or controlling emissions of greenhouse gases
Adaptation: Taking actions to help communities and ecosystems to cope with changing climate conditions
Resilience: Capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience
Greenhouse Gases (GHG): Gases that trap heat in the Earth's atmosphere through absorbing infrared radiation; e.g. carbon dioxide, methane, ozone, etc.

[1] https://www.globalcovenantofmayors.org/about/

History of Environmental Resiliency in Norfolk

The following timeline outlines key events in Norfolk's recent history that increase resiliency in the city. The Mayor's Advisory Commission on Climate Change Mitigation and Adaptation complements the following actions and events by creating and increasing city efforts to mitigate greenhouse gases and further adapt to climate change. Important dates referenced in the Climate Action Plan are also included in the timeline.

- → **September 30, 2009:** City of Norfolk's Idling Policy for City Vehicles & Equipment goes into effect
- → **August 19, 2011:** The Tide light rail opens in Norfolk
- → **January 2012 –** Draft 2010 Greenhouse Gas Inventory from Old Dominion University
- → **2013:** Fugro Atlantic releases *Coastal Flooding Mitigation Master Plan*, mentioning the "potential to enhance the waterfront corridor between downtown and Harbor Park," in Norfolk
- → **March 26, 2013:** City Council adopts a new general plan for Norfolk, *planNorfolk2030,* to guide decision making about physical development and public infrastructure
- → **December 3, 2013**: Norfolk is selected by the Rockefeller Foundation to be one of the inaugural 33 cities joining the 100 Resilient Cities Network
- → **2015:** City Council adopts the Complete Streets policy, included in *plaNorfolk2030*
- → **Summer 2015:** The Dutch Dialogues event recommends "living with the water" by taking advantage of the riverfronts and stream alignments to improve water quality, reduce catastrophic/recurrent flooding, and improve ecosystems and connectivity to adjacent neighborhoods
- → **October 28, 2015:** The City of Norfolk releases Norfolk's Resilience Strategy, becoming the third city in the world to launch such a plan
- → **December 2015:** City Council adopts the Bicycle and Pedestrian Strategic Plan
- → **January 2016:** Commonwealth of Virginia – City of Norfolk awarded the National Disaster Resilience Competition for the Ohio Creek Watershed Project
- → **November 22, 2016:** City Council adopts Vision2100, a plan to transform Norfolk into a resilient waterfront community, making the city THE coastal community of the future with the capacity to endure and quickly recover form climatic and environmental shocks and stresses
- → **December 2017:** City Council approves installing electric charging stations in city garages through a partnership with Tesla
- → **June 1, 2017:** Mayor Kenneth C. Alexander signs the Global Covenant of Mayors for Climate and Energy, formally symbolizing Norfolk's goal to combat climate change
- → **July 18, 2017:** Norfolk City Council unanimously opposes offshore drilling, as well as seismic testing
- → **2018:** City Council adopts a rewrite to Norfolk's Zoning Ordinance, including the Resilience Quotient

- → **January 23, 2018:** City Council signs an ordinance establishing the Mayor's Advisory Commission on Climate Change Mitigation and Adaptation to assist the city in meeting the goals of the Global Covenant
- → **March 26, 2018:** The Mayor's Advisory Commission on Climate Change Mitigation and Adaptation first meeting
- → **April 6, 2018:** PACE bikeshare launches in Norfolk
- → **May 8, 2018:** The Tide light rail hits 10 million rides
- → **Summer 2018:** The City of Norfolk's Public Works Department begins drafting a plan to transition city streetlights to LED
- → **June 2018:** Norfolk Zoo reduces its plastic waste by eliminating plastic straws and transitioning its catering and food service products to recyclable and compostable
- → **July 10, 2018:** City Council adopts the Green Infrastructure Plan
- → **August 2018:** Hampton Roads Transit receives grant to purchase battery-powered electric buses
- → **February 5, 2019:** Signed Chief's Report for Norfolk's Coastal Storm Risk Management Study marking the formal completion of the study
- → **March 25, 2019:** Final meeting of Mayor's Advisory Commission on Climate Change Mitigation and Adaptation

Overview of Commission

To advise the city on a Climate Action Plan, City Council unanimously established the Mayor's Advisory Commission on Climate Change Mitigation and Adaptation (Commission) on January 23, 2018. The Commission is comprised of experts, advocates, residents, business and nonprofit leaders to help craft an implementation-focused roadmap to address Norfolk's changing climate. The Commission first met on March 26, 2018, and then nearly once a month every month following until March 25, 2019. The Commission provides advice and input to the Mayor and Council concerning factors impacting climate and its impact on citizens.

At the first meeting, the Commission members defined its mission. The mission is:

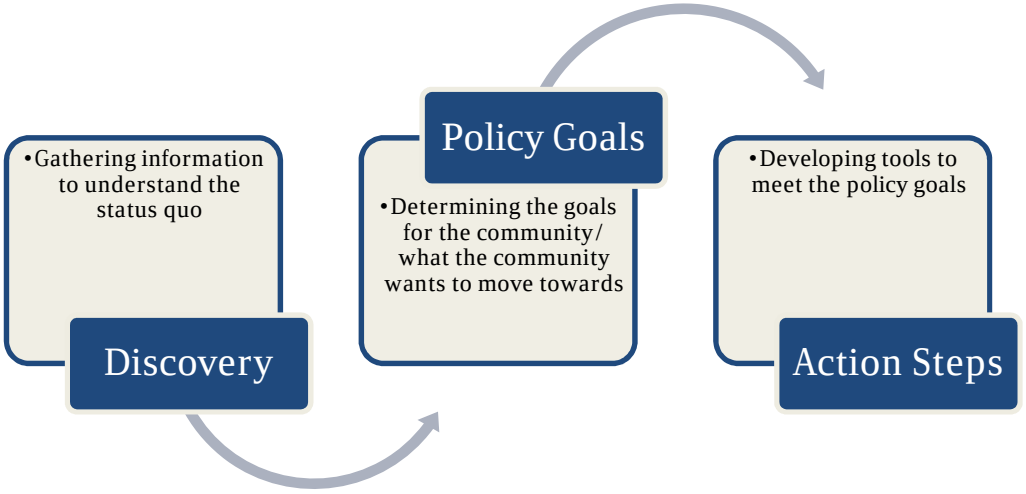
"*To identify measurable, achievable goals for cutting Norfolk's carbon emissions, to mitigate and adapt to climate change, and to position the City of Norfolk as a vibrant, resilient, healthy, and economically flourishing city.*"

The Commission is comprised of 29 members, appointed by City Council, who represent a variety of relevant perspectives. The Commission draws on the individual and collective talents and resources of its members to:

- Understand and analyze issues regarding climate change in Norfolk;
- Use expertise to set goals, targets, and strategies to reduce carbon emissions in Norfolk; and
- Make recommendations that lead to collective action.

To guide its work, the Commission was divided into three sub-committees: Large Institutions, Neighborhood/Residential, and Transportation.

The Commission developed the Climate Action Plan through a three-part process: Discovery, Policy Goals, and Action Steps.



Phase One: Discovery

Old Dominion University presented the Draft 2010 GHG Inventory to the commission. The city shared work already underway related to environment resilience and commission members shared initiatives underway from their respective organizations. Informational interviews occurred with other Virginia cities and counties for best practices and the commission also reviewed other U.S. cities Climate Action Plans.

2010 Greenhouse Gas Inventory:

The 2010 Greenhouse Gas (GHG) Inventory was prepared for the City of Norfolk by the Old Dominion University Civil and Environmental Engineering Department (Mujde Erten-Unal, Ph.D., Associate Professor; Joseph McCloud, MS Environmental Engineering; John D. Whitelaw, Ph.D. Candidate) in January 2012. A GHG inventory helps local governments manage climate risk and promote environmental stewardship, as well as effectively address inefficiencies within processes and operations. The inventory provides the City of Norfolk with an emissions baseline and understanding of the various sources of emission and their magnitudes. This baseline is used to develop strategies for future reduction of GHG emissions.

The inventory contains two distinct sections: Government Analysis and Community Analysis. Government Analysis is composed of ten reporting sectors and represents an in-depth account of all emissions associated with operations in Norfolk. The Government Analysis was performed in accordance with the Local Government Operations (LGO) Protocol, International Council for Local Environmental Initiatives (ICLEI) 2010.

The Government Analysis makes up a small subset of the larger Community Analysis, which includes emissions for all sources within the geographic footprint of the City of Norfolk. The Community Analysis was conducted in accordance with the U.S. Community Protocol, ICLEI 2012. GHG emissions for both the Government Analysis and Community Analysis totaled approximately 3.9 million metric tons of CO2e (carbon dioxide equivalent). **City of Norfolk municipal operations made up just under 5-percent of total emissions.** The GHG Inventory was conducted based on the best available data and in accordance with the most up to date calculation methods at the time.

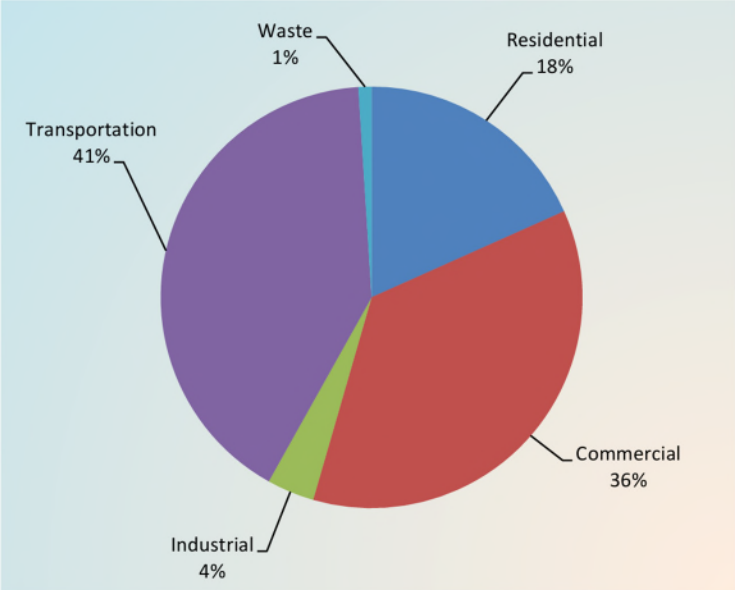


Figure 1 - Norfolk Community Emissions by Source - ODU GHG Inventory

Peer Review:
After reviewing the Climate Action Plans and Community Energy Plans of Blacksburg, Roanoke, and Arlington, the Commission interviewed city staff responsible for the plans in those cities. This helped the Commission understand best practices, the Climate Action Plan development process, and unique challenges faced by Virginia cities.

Questions for city and county staff involved the planning process (setting goals, targets, and strategies), prioritizing and quantifying targets, metrics, helpful tools, unexpected challenges and successes, how to engage the community, and resources used to design the plan and outreach. The major takeaways from these interviews include:

- Climate Action Plans are an "evolving art" and communities continue to learn from one another.
- The Paris Accord goals may seem intimidating at current emission levels and with limited resources, but every action taken toward reducing carbon emissions counts.
- Quantifying goals is an educated guess; metrics and data may change as new information and technology becomes available.
- Efficiently developing a Climate Action Plan requires collaboration, collective impact, and conversation framing; stakeholders (City, industry, businesses, residents, etc.) must all be allowed a voice in a genuine heart-to-heart conversation to understand where goals align.

Norfolk Strategic Documents:
The Climate Action Plan complements the work already underway. The following documents have been approved by City Council and/or the administration and contain goals and actions in support of the Climate Action Plan. Each document's vision and impact on carbon emissions and energy efficiency is detailed below.

plaNorfolk2030
On March 26, 2013, City Council adopted *planNorfolk2030,* a new general plan for Norfolk. *plaNorfolk2030* guides decision making regarding physical development and public infrastructure. The plan contains the broad outlines neighborhoods will use to guide and plot their path to the future. It is flexible, allowing for appropriate response to changes in development patterns.

plaNorfolk2030's vision is to create a great place to live, work, and play. Goals in line with those of the Climate Action Plan include not only sustaining, but protecting the environment, as well as creating a comprehensive, multi-modal transportation system. This vision directly and indirectly reduces carbon emissions in Norfolk.

Norfolk's Resilience Strategy

Norfolk has adopted a key focus for its future – that of being a resilient city. On December 3, 2013, Norfolk was designated by the Rockefeller Foundation as one of the inaugural 33 cities part of the 100 Resilient Cities Network. In October 2015, with aid from the foundation, Norfolk became the third city globally to adopt a resilience strategy. As a city whose 66 square mile area is about a third water, living with water is a key theme for the city's resilience strategy. A key theme of the Resilience Strategy is living with water by designing the coastal community of the future. Creating a resilient Norfolk directly and indirectly reduces carbon emissions and increases energy efficiency as the city finds innovative solutions to increase sustainability.

City of Norfolk Bicycle and Pedestrian Strategic Plan

In December 2015, City Council adopted the City of Norfolk Bicycle and Pedestrian Strategic Plan. The plan details 12 corridors that citizens identified as streets where they would most like to see bike facilities. The plan ensures biking and walking are a safe and convenient means of daily travel for all Norfolk residents and visitors. This plan is one example of how the city implements the Complete Streets policy (see *Complete Street Policy* on page 12).

Granby Street: Granby Street is the main corridor through Norfolk's growing Arts and Design District. The Revitalization Strategy for this area identified a preferred shared lane bicycle treatment between Brambleton Avenue and Virginia Beach Boulevard as depicted in the rendering above.

The Climate Action Plan supports the Bike & Pedestrian Strategic Plan. An increase in bike and pedestrian traffic can lead to a decrease in reliance on automobiles, decreasing carbon emissions attributed to automotive transportation in Norfolk.

The Climate Action Plan supports full integration of the Bicycle and Pedestrian Strategic Plan into city policies and plans, including PlaNorfolk2030. Full integration requires that all transportation agencies within the city routinely plan, fund, design, construct, operate, and maintain streets according to the Complete Streets principles of the Bicycle and Strategic Plan.

Zoning Code Rewrite – ***Most Resilient Zoning Code in the Country***

Norfolk's new zoning ordinance was unanimously adopted by City Council on January 23, 2018 and took effect on March 1, 2018. The ordinance was rewritten to strengthen the City's commitment to vibrant neighborhoods, economic diversity, and coastal resilience. The new zoning ordinance encourages and supports development that makes Norfolk more resilient, both physically and

economically; recognizes four established character districts; and enhances the user experience through an improved format and streamlined development processes.

The zoning ordinance includes pioneering approaches in response to the long-term challenges posed by sea level rise, one of which requires all development within the City to meet a resilience quotient. The requirement is measured on a points system covering three separate resilience elements: risk reduction, stormwater management, and energy resilience. This innovative points system ensures that new development will be more resilient and environmentally-friendly while providing flexibility to builders by allowing them to choose which measures to include in the development. Additionally, new or expanding development must meet minimum requirements for first floor elevations ranging from 1.5 feet above grade level to 3 feet above flood level, prohibiting basements. The zoning ordinance allows for easier mixing of uses in commercial corridors to encourage more vibrant and pedestrian-friendly communities, whether one walks, bikes, uses transit or drives.

The Resilience Quotient is significant for the Climate Action Plan and energy use in Norfolk. Techniques seeking to promote energy resilience include energy conservation and use of alternative energy. Examples of techniques include installing renewable energy systems, installing geothermal heating and cooling systems, adopting an energy efficient budget, planting vegetation to shade and cool buildings, and providing electric vehicle charging stations.

Vision2100

Norfolk's zoning ordinance addresses planning and development today, the city has also used the challenge of sea level rise to create a vision to guide decision making in the future. Vision2100 looks further out than the typical 20-30-year land use planning horizon and, instead, takes a long view 80+ years in the future. Over a year, the city hosted public meetings where residents identified places, events, and items in their neighborhoods that make Norfolk a great place to live, work, and play. By working with residents, the city is building a long-term strategy to address the flooding challenges due to sea level rise. How the city uses land today will help ensure the opportunity that Norfolk will be a dynamic, water-based community into the next century. Through Vision2100 the city is designing new urban centers, enhancing economic engines, adapting to rising waters, and establishing neighborhoods of the future. The statements, goals, and actions in Vision2100 provide broad guidance to the city's decision makers.

Green Infrastructure Plan

City Council adopted Norfolk's Green Infrastructure Plan in July 2018. The plan seeks to design the coastal community of the future by using the city's natural assets to improve environmental and community health and to protect infrastructure. Just as the city plans for its 'gray infrastructure,' such as roads, sidewalks, and storm drains, it must plan for its 'green infrastructure', including the marshes, creeks, parks, and trees that provide habitat, filter the air and water, moderate air temperatures, and provide recreation and scenic beauty. These green features are referred to as 'green infrastructure'.

The Green Infrastructure Plan helps the city realize new or expanded benefits from its green infrastructure such as clean water, recreation, stormwater uptake, storm buffering, habitat protection and walkable, vibrant neighborhoods. These interventions have the effect of directly and indirectly reducing carbon emissions as residents and visitors can more easily travel around Norfolk on foot or active transportation, as well as building green infrastructure that absorbs carbon.

Undergoing Carbon Reducing/Energy Efficiency Actions:
The Commission spoke with multiple City Departments to document what actions the City has already undertaken that may reduce carbon and/or increase energy efficiency. Departments are undertaking both larger actions that change the infrastructure of Norfolk and seemingly smaller, but just as impactful, every day actions.

Idling Policy
On September 30, 2009, Norfolk's Idling Policy for City Vehicles & Equipment (Policy and Administrative Regulations, 9.2) went into effect. The policy requires that "City Equipment will not be stationary with the engine operating for more than five (5) consecutive minutes, in a 60-minute period, unless it is essential for performance of work or otherwise specified…", as well as that "Departments, led by Fleet Management, will continually seek technical innovations and alternative or lower fuel-use auxiliary equipment and/or attachments to existing equipment to avoid idling." The City's Idling Policy helps reduce carbon emissions in Norfolk through mandating engines not be turned on and stationary, as well as increases energy efficiency by requiring departments use cleaner, greener vehicles and equipment.

Complete Streets
To allow for a multimodal city, Complete Streets are streets that are designed—or redesigned—and operated to allow safe access to all people, regardless of age, ability, income, ethnicity, or chosen mode of travel, including pedestrians, bicyclists, motorists and transit riders. The Complete Streets policy was adopted by City Council in 2015. The policy calls for Norfolk to develop, operate and maintain an integrated, connected network of streets that are safe and accessible for all people, regardless of age, ability, income, ethnicity, or chosen mode of travel, including pedestrians, bicyclists, motorists and transit riders, in a balanced, responsible and equitable manner consistent with and supportive of the surrounding community.

One of the needs the Complete Street Policy meets is combining environmental strategies, increasing opportunities for environmental stewardship through the addition of green infrastructure, reduction of

fuel consumption, and reduced demand for motor vehicle infrastructure. These opportunities help reduce transportation carbon emissions in Norfolk.

Multimodal City

Norfolk is a multimodal city. The Tide light rail opened to the public in August 19, 2011. On average, 4,500 passengers ride the light rail each weekday. During the planning of the light rail, it was estimated that the light rail would have 2,900 weekday riders. On May 8, 2018, the Tide light rail reached a milestone – 10 million rides since opening. The Tide light rail helps reduce carbon emissions in Norfolk by providing alternative transportation to a car for those living and working in Norfolk.

The PACE bikeshare launched in Norfolk in April 6, 2018. Bikes are spread across the for those living, working, or visiting in Norfolk to rent. The bikes help users traverse around Norfolk in a quick and easy way with no emissions, rather than car, vehicle ride sharing, taxi, public transit, et cetera. This alleviates not only carbon emissions, but also traffic congestion and parking demand.

LED Transition

The city plans to transition all street and pedestrian lights to LED (light emitting diode). LED lights require less energy than the lights used now, increasing energy efficiency in Norfolk. The lights have a higher upfront cost, but over time may present long-term savings to the city.

Green Fleet

The City is in the process of transitioning the City fleet to be made up of clean energy vehicles. As old city vehicles break down and become unrepairable, General Services' plan is to replace where practicable with hybrid and clean energy vehicles. This increases the energy efficiency of the City's fleet.

Central Energy Plant

The Central Energy (CNG) Plant controls the energy efficiency of some city buildings (e.g. City Hall, Norfolk Courthouse, Slover, and the School Administration Building) by controlling building climate. The plant controls building climate through setting the temperature and range, about 2 to 4 degrees Fahrenheit. The CNG Plant increases energy efficiency through variable frequency devices (VFDs). VFDs slowly power up pumps and stop once the needed energy level is met. Rather than completely relying on electricity to power the HVAC system and cool buildings, VFDs use chilled water pumps. Chilled water pumps reuse water as well decrease electricity use. The city plans to explore the feasibility of adding additional public structures to the CNG.

EnergyCap Software

To pay utility bills, General Services is transitioning to EnergyCap Software to make the process electronic rather than manual. Under the current system, utility usage and bills for all 200 City buildings is manually entered and paid. The new software will allow the City to see trends in utility usage. EnergyCap Software was piloted with the 12 City fire stations. Once the software is

implemented city-wide, the City will be able to see energy and water usage and trends for all buildings. This allows the City to understand trends and spot and address abnormalities. For example, if a spike in energy occurs, the City can understand if it is related to the weather, the set temperature range, or a malfunction in energy management. This system has the potential to save energy and money and increase energy efficiency.

Keep Norfolk Beautiful

Keep Norfolk Beautiful (KNB) is part of the City and a branch of Keep America Beautiful. KNB focuses on reducing litter, recycling correctly, and beautifying Norfolk. Operated by a small staff, KNB relies on volunteers to accomplish its goals. During FY 2017, KNB worked with 7,901 volunteers a 16 percent increase from FY2016. This equates to 21,495 volunteer hours, or total value added of over half a million dollars. KNB activities and programs include: calculating a Litter Index, city cleanups, working with the Norfolk Tree Commission, Norfolk Environmental Commission, and Virginia Cooperative Extension, promoting resilience, and educating Norfolk residents to change behavior and mitigate litter and waste.

KNB collaborates with City Departments, including Stormwater, the Office of Resilience and Recreation, Parks and Open Space. Collaborative projects include Adopt a Storm Drain, Retain Your Rain, and Rain Barrels. Adopt a Storm Drain encourages community members and neighborhoods to help keep storm drains litter free to help reduce flooding. Retain Your Rain also helps reduce flooding through helping residents incorporate green infrastructure at home to keep storm water off the street. Rain Barrels also aid with water catching.

KNB's philosophy is to start small. It encourages residents to become more conscious of their environmental impact starting with reducing litter and stormwater in the street. Residents become more environmentally conscious as they reduce litter, potentially leading them to find other ways to improve the local environment, including reducing carbon emissions and increasing energy efficiency.

City Landscape

The City of Norfolk's Recreation, Parks and Open Space (RPOS) department has already implemented actions that directly reduce carbon emissions. In maintaining city landscape, RPOS minimizes maintenance through planting perennial plants and flowers rather than annuals. Perennials are easier to maintain, reducing the need to use gas-fueled landscaping equipment and machinery, as well as do not require pesticides.

Building Efficiency

Actions made by General Services that increase energy efficiency include: replacing old, broken down AC units with more energy efficient units; transitioning lighting in buildings and parking garages to LED; installing automated towel dispensers, faucets, toilets, and lights in City Hall restrooms, as well as throughout Slover Library and New Courts Building. The New Courts building was built to be energy efficient, including glass hallways to allow for natural light, energy efficient windows with thermal

panes so they are the temperature of the room, rather than the outside temperature, window covers to shield from heat, LED and automatic shut off lights, and motion detectors on lights.

Enhancing Transportation Efficiency
Both Waste Management and City Utilities use a GPS system to travel around Norfolk. This limits the time and distance trash trucks and vehicles drive through optimizing routes and reducing idling and wear and tear. This not only reduces fuel consumption, creating cost savings, but also reduces carbon emissions and increases energy efficiency.

Phase 2: Setting Goals, Targets, Strategies

Each goal section in this Climate Action Plan includes an overarching goal, measurable targets, and action strategies. To determine goals, the commission identified areas in Norfolk that could have the biggest impact on reducing carbon and/or increasing energy efficiency. These areas were selected using best practices from other cities' Climate Action Plans, analyzing Norfolk's GHG Inventory, and understanding the nature of Norfolk. A single, overarching goal was drafted for each action area. The goals are meant to be progressive, but with significant progress by 2050 without negatively impacting the economic growth in Norfolk. The Climate Action Plan will not address strategies related to flooding or green infrastructure since there are already strategies underway to address these critical areas. The focus of the Climate Action Plan is to supplement the flooding mitigation and adaptation work with a focus on reducing greenhouse gas emissions.

The commission focused on targets and strategies within following goal areas in the plan:

- Renewable Energy Production: Increase usage of renewable energy
- Buildings & Energy Use/Efficiency: Increase building and operation energy efficiency and reduce energy consumption
- Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
- Consumption & Waste: First reduce, then reuse, then recycle
- Food & Agriculture: Create and promote a sustainable food system
- Engagement, Outreach, & Education: Environmental education and engagement

Each goal is divided into measurable targets, both quantitative and qualitative depending on the nature of the data. Each target contains actionable strategies to meet the goals. Each strategy includes further criteria to understand why these strategies were finally chosen; these criteria include: impact, timeline, benefits, and authority. Impact qualifies a strategy's potential to reduce greenhouse gases as small, medium, large. Timeline anticipates the year in which a strategy is completed; these years are 2020, 2025, 2030 or later – referred to as short-term, medium-term, long-term. Benefits are the positive effects of a strategy beyond reducing greenhouse gases; the benefits were chosen using City priorities: health, job creation, cost savings, and equity. Authority is the lead and partner agencies responsible for carrying out the strategy; agencies include both public and private entities.

Strengths, Weaknesses, Opportunities & Constraints

To help develop goals, targets and strategies that would have the most impact on reducing carbon emissions in Norfolk, the Commission discussed the strengths, weaknesses, opportunities, and constraints. This helped guide each sub-committee to make proactive but realistic recommendations as the reviewed targets and strategies for their sector.

Strengths – The Commission identified an engaged community, ranging from active Civic Leagues, non-profits, higher education institutions to advocacy groups. The Commission also identified that it would be in many sectors of the community's best interest to reduce their carbon footprint through reduced energy costs.

Weaknesses – The municipal government is fiscally restrained and many of the recommendations will compete with other priorities. The commission also identified the importance of not limiting economic growth through increased regulations or costs. There is also a weakness of a lack of education or understanding of the issue within the general public.

Opportunities – The ability to become a leader in the Commonwealth like the city's leadership with coastal resilience. The opportunity to infuse carbon cutting measures into redevelopment projects in the city.

Constraints - In Virginia, local governments are limited to the powers expressly granted to them by the state. This is referred to as the Dillon Rule. Historically, the Commonwealth of Virginia has taken limited steps to address the changing climate and has not provided local governments with the authority to limit their overall cities carbon footprint. As an example, local governments in Virginia are not allowed to ban plastic bags or straws within their municipality unless the Virginia General Assembly specifically grants localities that power.

Phase 3: Recommendations

The Commission met monthly between March 2018 and March 2019 to draft recommendations. In addition to meeting as a group, members reviewed data, and thoughtfully explored a wide range of concepts and best practice models to arrive at the following recommendations.

The goals, targets, and strategies summarized on the following pages are designed to promote carbon reduction and/or energy efficiency in Norfolk. Detailed action steps, GHG impact, timeline for implementation, secondary benefits and community leads are identified if applicable.

Goal	Renewable Energy Production: Increase usage of renewable energy
Target	Increase supply of non-carbon renewable energy used citywide from renewable resources (e.g., solar and wind) by at least 20 MW per year through 2025; and 30 MW per year through 2050. Municipal usage will add at least 10MW per year through 2035.

Strategy	Expand and resource/staff within the city responsible for the implementation of Climate Action Plan goals and identification of grant resources and financing (e.g., SunShot Initiative, Rockefeller Foundation.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health, Job Creation, Equity, Cost Savings	Municipal Government	Not Applicable

Strategy	Solar Survey - Inventory all municipal and school building rooftops for solar PV and hot water potential; Identify all municipal or authority open land for potential solar installation (i.e. Norfolk Airport); Identify all non-municipal government owned property for solar PV and hot water; Prioritize areas by locations in opportunity zones.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate/Large	Job Creation, Cost Savings	Municipal Government	Private Sector

Strategy	PACE - Implement PACE (property assessed clean energy) funding mechanism to allow for financing of renewable energy by commercial, non-profit, multifamily properties.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate/Large	Job Creation, Cost Savings, Health, Equity	Municipal Government, Financial Institutions	Chamber of Commerce, Advocacy Organizations

Strategy	Public Solar – Encourage the use of solar on municipal and school facilities. Work with city staff and Norfolk Public Schools to develop an RFP for solar on municipal and school facilities.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Job Creation, Equity, Cost Savings, Health	Municipal Government, School Division	Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Residential Solar – Increase the residential solar deployed in Norfolk by 100 households per year for the next 10 years: Participate in the American Solar Energy Society (ASES) annual solar home tour; Advertise this through all city channels; Encourage banks to advertise low-interest loans for installation of solar; Include links to information on solar on the city's website.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate	Job Creation, Equity, Cost Savings	Municipal Government, Financial Institutions, NGOs	Advocacy Organizations

Strategy	Municipal Green Power Purchasing - Enact a policy for purchasing green power or installation of solar PV systems in municipal buildings, wherever practicable; Policy to include creation of a subcommittee of The Virginia Energy Purchasing Governmental Association (VEPGA) for municipal renewable power purchasing.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Cost Savings, Job Creation	Municipal Government	Virginia Department of Environmental Quality

Strategy	State Energy Policy - Participate in statewide policy discussions to expand the market in Virginia for renewable energy; Include support of a regional greenhouse gas initiative in Norfolk's legislative agenda; Support and advocate for Governor Northam's new policy to implement renewable resources. Advocate for creation of an open data policy for energy providers.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Job Creation, Cost Savings, Equity, Health	State Government, Municipal Government	Hampton Roads Planning District Commission, Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Sustainable Business Coalition - Create a recognition and incentive program for commercial purchases of green energy, to possibly include future tax incentives, procurement guidelines, and prioritization of municipal contracts from coalition members; Educate businesses about how to finance solar with bi-annual seminars and online resources shared with business partners.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate	Job Creation, Cost Savings	Municipal Government, Chamber of Commerce, Norfolk Environmental Commission,	Hampton Roads Planning District Commission, Advocacy Organizations

Strategy	City code and financing - Remove financial barriers to building retrofits, including limiting net property tax increases due to completed energy projects; Promote the use of renewable energy through supportive code changes to permit and require the use of new technologies, such as solar and wind power, while ensuring such technologies are compatible in established residential areas.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Small/Moderate/ Large	Job Creation, Cost Savings	Municipal Government	Private Sector

Strategy	Solar Emergency Shelters - Create resilient shelters by installing solar plus battery backup at schools and existing shelters; identify potential grant assistance. Bring on one shelter per year.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Small, Moderate	Job Creation, Cost Savings, Equity, Health	Municipal Government, School Division	Private Sector, Philanthropic Community

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Renewable Energy Production: Increase usage of renewable energy
Target	Meet 5% of Norfolk Redevelopment and Housing Authority (NRHA) residential energy demand with on-site photovoltaics (PV) systems by 2020 and 25% by 2030.

Strategy	Workforce Development/Green Jobs - Create workforce development opportunities and credentialing for green jobs for Norfolk residents with a target to NRHA communities. (NPS, TCC, Centura, etc.) Enroll at least 50 residents annually in green job training programs.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term/Long-term	Small, Moderate	Job Creation, Cost Savings, Equity, Health	Higher Education Institutions, Norfolk Redevelopment and Housing Authority	Municipal Government

Strategy	Solar on Public Housing – Work with NRHA to identify funding sources and mechanisms to install solar PV for 5 percent of energy demand.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term/Long-term	Small, Moderate	Job Creation, Cost Savings, Equity, Health	Higher Education Institutions, Norfolk Redevelopment and Housing Authority, Municipal Government	Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Buildings & Energy Use/Efficiency: Increase building and operation energy efficiency and reduce energy consumption
Target	Optimize energy efficiency of existing buildings and facilities, with a goal of reducing municipal building energy usage by 5% per year and reducing energy usage by 45% by 2030. Reduce overall building energy use citywide by 3% per year and 30% by 2030.

Strategy	Replace city equipment with energy efficient upgrades when equipment is refreshed (LED lights, HVAC, etc.); Institute and upgrade program and codify policy in city plan. Set an initial minimum of 18 SEER for any HVAC system used in a refresh. Use LED light in any facility renovation. Target at least 5 major facilities per year for conversion to LED; Prioritize hiring of local Norfolk Redevelopment and Housing Authority (NRHA) residents for energy efficiency projects.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Cost Savings, Health, Job Creation, Equity	Municipal Government	Virginia Department of Environmental Quality, Norfolk Environmental Commission, NRHA

Strategy	Incentives/Finance for Commercial Energy Upgrades - Research opportunities for "green zones"; on-bill financing; tax incentives and PACE financing tools that would enable local businesses to cost-effectively pursue energy efficiency upgrades in their buildings and operations. Explore with philanthropic community zero-interest, short-term loans to retro-fit and upgrade public housing.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Cost savings, Job Creation	Municipal Government, Chamber of Commerce, Financial Institutions	Virginia Department of Environmental Quality, Norfolk Environmental Commission, Philanthropic Community, Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Perform energy performance analysis of all municipal buildings. Set a best practice standard for HVAC for municipal and school facilities of a minimum of 74 degrees for AC or 68 degrees for heating. Evaluate opportunities for retrofitting with geothermal projects. Prioritize energy efficiency capital projects for existing buildings in the annual CIP budget. Provide annual reports on energy usage.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate/Large	Cost savings, Job Creation	Municipal Government	Private Sector

Strategy	Outdoor LED Lights – Request replacement of all Dominion-owned municipal outdoor lights with LEDs by 20% per year. Any new municipal outdoor lighting to be installed must be LED or equivalent.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Cost Savings	Dominion/Municipal Government	Not applicable

Strategy	City Appliances Policy - require all city-owned facilities to institute polices regarding turning off equipment and appliances.: e.g., Energy Star methodologies to have all computers, monitors, printers go to sleep nights/weekends/holidays.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Cost Savings	Municipal Government	Not applicable

Strategy	Sustainable Business Coalition - Create Energy Performance Benchmarking program in conjunction with the Chamber of Commerce. Implement energy performance tracking and annual reporting program for commercial buildings and explore options for multifamily buildings.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Cost Savings, Job Creation, Equity	Chamber of Commerce, Private Sector	Municipal Government

Strategy	Central Energy Plant - Expand centralized plant control to include more municipal buildings and facilities.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate/Large	Cost Savings	Municipal Government	Not applicable

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	State Policy – Advocate with the state government to change state policy for best practices to incentivize utilities to decrease demand.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Large	Health, Job Creation, Cost Savings, Equity	Municipal Government, Hampton Roads Planning District Commission	Advocacy Organizations

Goal	Buildings & Energy Use/Efficiency: Increase building and operation energy efficiency and reduce energy consumption
Target	Increase construction of environmentally friendly, green buildings, facilities, and projects in municipal

Strategy	Increase the number of municipal projects with net zero energy consumption by constructing a demonstration project by 2025 and a having 100% of qualified, municipal construction projects built to achieve net zero energy consumption by 2030.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term/Long-term	Moderate	Job Creation	Municipal Government	Not applicable

Strategy	Enact a policy supporting City-financed projects ((including performance grants for development) to meet an energy efficiency standard, such as LEED, Energy Star standards, National Home Builders Association (NHBA) Green Building, or Earthcraft.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term/Long-term	Small/Moderate	Cost Savings	Municipal Government	Not applicable

Strategy	Resilience Quotient – Review and update the Resilience Quotient for buildings in the 2018 Zoning Ordinance every three years (aligning with building codes updates) to reflect new energy efficiency and resilient best practices, which encourage green building.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/ Medium-term/Long-term	Moderate/Large	Cost Savings, Job Creation, Equity	Municipal Government	Private Sector

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Industrial Energy Efficiency Programs - sponsor annual educational outreach of Department of Energy's Industrial Technology Program to the Norfolk business community, which sponsors energy audits for manufacturing plants.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term/Long-term	Moderate/Large	Health, Job Creation, Equity	Private Sector	Municipal Government

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
Target	Increase paved greenway infrastructure and natural surface greenway on city-owned to provide greater connectivity and more pleasant environment

Strategy	Regional Trail Infrastructure -Continue to work with the Elizabeth River Trail Foundation, city agencies and others to plan new trails or trail modifications to connect adjacent communities for cycling and walking infrastructure (for pedestrians of all abilities).			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity	Elizabeth Trail Foundation, Municipal Government	Greater Norfolk Corporation, Private Sector

Strategy	Designing with Nature - Promote and require urban design and redevelopment approaches that incorporate natural systems and green infrastructure into site improvements, rights of way, green corridors and other infrastructure facilities.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Moderate/Large	Health, Job Creation, Equity, Cost Savings	Municipal Government	Norfolk Environmental Commission, Local Architects & Landscape Designers

Goal	Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
Target	Increase use of bike lanes

Strategy	Active Commute Incentives - Offer (non-financial) incentives or otherwise encourage residents to bicycle or walk to daily destinations.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate/Large	Health, Equity	Norfolk Bike Commission, Norfolk Environmental Commission	Advocacy Organizations, Elizabeth River Trail Foundation

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Funding - Apply for and secure grants and other (non-financial incentives) to support sustainable transportation initiatives.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Moderate	Health, Equity	Municipal Government	Elizabeth River Trail Foundation, Norfolk Bike Commission, Norfolk Environmental Commission

Strategy	PACE Bikes - Support PACE bikeshare program to increase frequency of current riders; Incentivize new riders to join; Promote/Incentivize PACE as transportation to City events, e.g. Harborfest.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health, Equity	PACE, Municipal Government	Elizabeth River Trail Foundation, Norfolk Bike Commission, Norfolk Environmental Commission, Downtown Norfolk Council

Goal	Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
Target	Increase fuel efficiency and use of clean fuel in automotive modes of transportation

Strategy	City Vehicles - Support the City's No Idling Policy for municipal vehicles and implement a system to track idling and vehicle use; support and find new ways to reduce municipal vehicle use, modeled after Waste Management Policy.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health, Cost Savings	Municipal Government	Not applicable

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Alternative Fueling Infrastructure - Help identify, implement, and increase resources to expand alternative fueling/charging stations around Norfolk. Encourage/incentivize/educate companies to use electric vehicles and add electric vehicle charging stations to parking lots.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Moderate	Health, Cost Savings	Chamber of Commerce, Municipal Government	Advocacy Organizations

Goal	Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
Target	Increase transit infrastructure and use of public transportation and non-auto modes of transportation. Reduce work-related transport emissions.

Strategy	Increase funding for transit through support for regional dedicated funding for public transit operations that connect to major employment, military, educational, and medical destinations.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Large	Health, Job Creation, Cost Savings	Hampton Roads Transportation Planning Organization, Hampton Roads Transit	Municipal Government, Hampton Roads Planning District Commission

Strategy	Foster Regional Planning - Work with adjacent localities to plan for regional transportation, housing, and infrastructure patterns that will minimize car-dependency and the conversion of green space, farms and forested areas. Continue to coordinate land use decisions for alternative transportation services.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Large	Health, Job Creation, Cost Savings	Hampton Roads Transportation Planning Organization, Hampton Roads Transit	Municipal Government, Hampton Roads Planning District Commission

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Live Where You Work and Work Where you Live – Support workers living within Norfolk and within walking or public transit distance to their employment. Encourage employers to include incentives and education for telecommuting.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term	Moderate	Health, Job Creation, Cost Savings, Equity	Municipal Government, Chamber of Commerce	Hampton Roads Transit, Advocacy Organizations

Strategy	Education - Increase awareness of the individual benefits of alternative and active commuting and the variety of options available in the community			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health, Equity, Cost Savings,	Municipal Government	Norfolk Environmental Commission, Bike Commission, Hampton Roads Transit

Strategy	Encourage Location Efficient Mortgages - Work with lenders on innovative lending practices to make Locational Efficient Mortgages (LEMs) available to people who meet an established standard of low car-dependency.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity, Cost Savings,	Financial Institutions, Municipal Government	Hampton Roads Transit, Realtors

Goal	Transportation: Increase energy efficiency, use of clean energy, and reduce vehicle reliance
Target	Increase use of fuel-efficient energy in public lighting

Strategy	Outdoor LED Lights - Support the installation of LED streetlights and traffic signals.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Cost Savings	Municipal Government, Dominion	Not Applicable

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Reduce average amount of household solid waste

Strategy	Education Campaign - Educate through media campaigns, giveaways, tabling, events, etc. to increase awareness of and participation in targeted waste-prevention practices for residents, businesses, and city departments, and research and encourage strategies for reducing use of paper, plastics and other materials.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate	Health, Cost Savings, Equity	Municipal Government	Civic Leagues, Schools, Advocacy Organizations

Strategy	Reusable Bags and Single-Use Plastics - Support incentive programs that encourage the recycling of plastic bags, or programs that give a discount to consumers who bring their own reusable bag and support legislation at the Virginia General Assembly allowing local governments to regulate the distribution, sale or offer of disposable plastic bags and other single-use products such as straws and extruded polystyrene food and beverage containers.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small	Health, Equity	Municipal Government, Chamber of Commerce	Keep Norfolk Beautiful, Private Sector, Advocacy Organizations

Strategy	Curbside Composting - Support Keep Norfolk Beautiful in identifying barriers to a composting program for single-family users; Begin finding solutions to overcome barriers.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate	Health, Job Creation, Equity, Cost Savings	Municipal Government/Keep Norfolk Beautiful	Norfolk Environmental Commission, Norfolk Botanical Gardens

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Coolant/Refrigerator Disposal -Evaluate potential changes to coolants/refrigerant disposal practices for discarded cars, refrigerators and AC units.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Health, Job Creation, Equity, Cost Savings	Municipal Government, Southeastern Public Service Authority	Private Sector – Automobile yards

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Increase municipal facilities and Norfolk Public Schools (NPS) recycling rates and decrease municipal and NPS waste/consumption.

Strategy	Green Purchasing Policy – Evaluate a potential Environmental Preferable Purchasing Policy for government operations and encourage its adoption more widely in the commercial/ industrial sector of Norfolk.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health	Municipal Government	Private Sector

Strategy	Child Education – Encourage Norfolk schools to educate students on the importance of reducing, reusing, then recycling; Have classrooms sign the askHRgreen Green Classroom Pledge. Expand efforts to faith-based organizations, Boys and Girls Club, etc.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health	School Division	Municipal Government, Norfolk Environmental Commission, Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Event Food Policy – Support a city policy that large city and school events include a plan to address food waste in a way that minimizes carbon emissions in event applications (e.g. donate, compost, etc.)			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Health	Municipal Government/School Division	Foodbank, Festevents, Chamber of Commerce, Soup Kitchens, Advocacy Organizations

Strategy	City Paper/Printing City Policy – Evaluate a potential purchasing policy that requires City departments to purchase recycled postconsumer content paper. In addition, multi-functional devices that utilize biological toners rather than chemical toners should be purchased when new devices are needed or need to be replaced.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small/Moderate	Cost savings	Municipal Government	Norfolk Environmental Commission

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Reduce commercial and industrial solid waste by 5 percent less per year

Strategy	When appropriate, promote alternatives to traditional building demolition such as relocation, deconstruction and salvage, including identifying and removing barriers and disincentives.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term	Moderate/Large	Health, Job Creation, Cost Savings	Private Sector	Municipal Government, Norfolk Redevelopment and Housing Authority

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Decrease use of regional landfill and encourage reuse of generated waste

Strategy	Landfill Gas - Support efforts to convert landfill gas to electricity.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term/Long-term	Moderate/Large	Health, Job Creation, Cost Savings	Southeastern Public Service Authority	Municipal Government

Strategy	Regional Waste Management – Evaluate potential changes to the regional waste management to ensure it is sustainable and promotes reuse.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Medium-term	Large	Health, Job Creation, Cost Savings, Equity	Southeastern Public Service Authority	Municipal Government

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Reduce litter around Norfolk to prevent storm drains from clogging and further exacerbating flooding.

Strategy	Support askHRgreen Programs - Encourage offices, schools, community groups, soccer teams, etc. to host their own Team Up 2 Clean Up by contacting Keep Norfolk Beautiful; Incentivize and encourage schools, youth groups, etc. to launch their own initiatives.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Small	Health, Equity, Cost Savings	Civic Leagues, Keep Norfolk Beautiful	Municipal Government

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Consumption & Waste: First reduce, then reuse, then recycle
Target	Reduce consumption-related carbon emissions by encouraging sustainable consumption and supporting Norfolk businesses in minimizing the carbon intensity of their supply chains

Strategy	Collaborate with business associations through a Sustainable Business Coalition to create an informal zero waste network.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term/Medium-term	Moderate/Large	Job Creation, Equity, Cost Savings	Private Sector, Norfolk Environmental Commission	Municipal Government, Chamber of Commerce

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Food & Agriculture: Create and promote a sustainable food system
Target	Increase access to affordable, nutritious foods in lower-income areas; decrease the number of residents that live in a food desert

Strategy	Eliminate Food Deserts - Support and improve access to farmers markets in neighborhoods with poor access to fresh foods and encourage local grocery stores to open locations in low-income areas. Advertise and encourage use of the Opportunity Zone program for investment in grocery stores in Qualified Opportunity Zones.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Small/Moderate	Health, Equity, Job Creation	Municipal Government, Philanthropic Community, Local Farmers	Norfolk Redevelopment and Housing Authority

Strategy	City Policy - Remove policy barriers preventing residents from starting smaller food businesses; Expand opportunities for food production and neighborhood-scale distribution including community gardens, especially for low-income populations and communities of color.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term,	Small/Moderate	Health, Equity	Municipal Government	Virginia Cooperative Extension

Strategy	City Policy and Programs - Develop policy and equitably provide programs to increase the production and consumption of home-grown and locally sourced food by supporting farmers markets and community supported agriculture (CSA).			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term,	Small/Moderate	Health, Equity	Municipal Government	Virginia Cooperative Extension

Strategy	Urban-Agriculture Pilot - Connect with local entrepreneurial groups for a pilot to explore opportunities to pilot "urban agriculture" and "agri-burbia" projects.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term,	Small/Moderate	Health, Equity	Municipal Government	Virginia Cooperative Extension

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Food & Agriculture: Create and promote a sustainable food system
Target	Educate and encourage residents to prioritize a lower-carbon diet

Strategy	Outreach and Education - Include healthy, low-carbon food choices in public and business outreach efforts. Work with partners to support efforts to encourage plant-based diets, including Meatless Monday campaigns.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity	Norfolk Environmental Commission, Municipal Government	Advocacy Organizations

Strategy	Outreach and Education - Collaborate with community groups to raise awareness of the energy and environmental impacts of different types of food production, processing, and transport.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity	Norfolk Environmental Commission, Civic Leagues	Advocacy Organizations

Goal	Food & Agriculture: Create and promote a sustainable food system
Target	Increase the amount of locally sourced produced and other foods in school meals by 50% by 2030

Strategy	Farm to School - Work with the Norfolk Public School District, private schools, and/or childcare facilities, and local food advocates to pilot a "Farm to School" program, incorporating locally-produced foods in student meals.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Small/Moderate	Health, Equity, Job Creation, Cost Savings	School Division	Advocacy Organizations, Local farms

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Add gardens in at least 5 public schools by 2025; Establish gardens in all public schools by 2050			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term, Long-term	Small/Moderate	Health, Equity	School Division	Virginia Cooperative Extension, Master Gardeners

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Engagement, Outreach, & Education: Environmental education and engagement
Target	Increase education on Climate Change and carbon reduction

Strategy	K-12 Sustainability Curriculum – Norfolk Public Schools and Private Schools to implement a sustainability curriculum for all K-12 schools, using existing lessons on how to audit your school/classroom for energy use, how to improve energy efficiency of your school, to proposing plans for alternative power including funding sources and for projects to improve carbon absorption through tree plantings etc. Students should develop annual projects to reduce the carbon footprint of their schools and homes.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate/Large	Equity, Health	Norfolk Public Schools, Virginia Department of Education, Municipal Government	Norfolk Environmental Commission, Advocacy Organizations

Strategy	University Assistance – Partner with local universities to increase education on climate change and carbon reduction.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity, Cost Savings	Local Universities, Municipal Government	Norfolk Environmental Commission, Advocacy Organizations

Strategy	Alignment with Community Efforts -Identify and seek resources to support community based initiatives, leveraging programs such as libraries, schools, health clinics, and faith-based groups that align with climate change preparation priorities, carbon emission reduction efforts and low-carbon lifestyles. Target low-income areas.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Moderate	Equity, Health	Municipal Government, Norfolk Environmental Commission	Advocacy Organizations

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Goal	Engagement, Outreach, & Education: Environmental education and engagement
Target	Integrate carbon emission goals into all city planning, activities, events, and actions

Strategy	City Website – Create a section on City of Norfolk's website with information on reducing carbon/sustainable actions, education, news, events, etc. relating to climate change mitigation. Education for residents, businesses, local organizations, large institutions. Include: carbon emission education, financing solar, energy star, telecommuting, 'zero-waste', river star homes, etc.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term	Small	Health, Equity	Municipal Government	Norfolk Environmental Commission

Strategy	Create a City led 'Your Sustainable City' campaign - Convene sustainability programs from multiple City bureaus under a "Your Sustainable City" umbrella campaign to inform and engage residents in City actions. Provide information to community organizations and civic leagues to share with their members.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate	Health, Equity	Municipal Government	Norfolk Environmental Commission

Goal	Engagement, Outreach, & Education: Environmental education and engagement
Target	Increase regional efforts in coordinating activities to reduce carbon emissions

Strategy	Regional GHG – Secure funding and execute a complete, regional greenhouse gas inventory.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Small/Moderate/ Large	Health, Equity	Hampton Roads Planning District Commission	State Government, Municipal Government

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Strategy	Regional Planning - Encourage prioritization of Climate Change Planning by the Hampton Roads Planning District Commission and regional adoption of a climate change planning policy to unify local planning and design efforts across the region.			
Timeline	**Impact on GHG**	**Secondary Benefits**	**Lead Agency**	**Partner Agency**
Short-term, Medium-term	Moderate/ Large	Health, Equity, Job Creation, Cost Savings	Hampton Roads Planning District Commission	State Government, Municipal Government

Short-term – 2020; Medium-term – 2025; Long-term – Post 2030

Appendix – 2010 Greenhouse Gas Inventory

Date: January 2012

DRAFT

2010 Greenhouse Gas Inventory

Prepared for

City of Norfolk, VA

Date: January 2012

Prepared by,
Mujde Erten-Unal, Ph.D, Associate Professor
Joseph McCloud, MS Environmental Engineering May 2013
John D. Whitelaw, Ph.D Candidate
Old Dominion University, Civil and Environmental Engineering Department
Norfolk, Virginia

OLD DOMINION UNIVERSITY

ICLEI Local Governments for Sustainability USA

Contents

Section **Page**

Acronyms and Abbreviations ..... **v**

Acknowledgements ..... **vi**

Executive Summary **1-1**
1.1 Government Analysis – Inventory Results 1-1
1.2 Community Analysis – Inventory Results 1-3

Introduction **2-5**
2.1 Background 2-5
2.2 Inventory Organizational Boundary 2-5
2.3 Methodology 2-6
2.4 Greenhouse Gas Reporting 2-7

Government Analysis **3-9**
3.1 Summary by Sector 3-9
3.2 Summary by Source and Scope 3-10
3.3 Detailed Sector Analyses 3-13
3.3.1 Buildings and Facilities 3-13
3.3.2 Streetlights and Traffic Signals 3-14
3.3.3 Port Facilities 3-15
3.3.4 Airport Facilities 3-15
3.3.5 Water Delivery Facilities 3-16
3.3.6 Wastewater Facilities 3-16
3.3.7 Solid Waste Facilities 3-18
3.3.8 Vehicle Fleet 3-19
3.3.9 Transit Fleet 3-19
3.3.10 Other Process Fugitive & Mobile Sources 3-20

Community Analysis **4-21**
4.1 Summary by Sector 4-21
4.2 Summary by Source 4-22
4.3 Detailed Sector Analysis 4-23
4.3.1 Residential 4-23
4.3.2 Commercial 4-23
4.3.3 Industrial 4-24
4.3.4 Transportation 4-24
4.3.5 Waste 4-27

Conclusions **5-30**

Appendixes
A References
B eGRID Electricity Emission Factors
C Example CO_2e Calculation

Section **Page**

Tables

1-1 2010 City of Norfolk Government Operations Emissions by Sector....1-2
1-2 2010 Norfolk Community CO_2e Emissions by Source....1-4
2-1 GHG Regulated Under the Kyoto Protocol....2-7
3-1 2010 City of Norfolk Government Operations Emissions by Sector....3-10
3-2 2010 City of Norfolk Government Operations Emissions by Scope....3-11
3-3 2010 City of Norfolk Government Operations Emissions by Source....3-12
3-4 Energy Use and Emissions from Public Lighting....3-14
3-5 2010 HRSD WWTP Emissions Summary....3-17
3-6 Calculation of Population Served for Each WWTP....3-18
4-1 Community CO_2e Emissions by Sector in 2012....4-22
4-2 Community CO_2e Emissions by Source in 2012....4-23

Figures

1-1 2010 City of Norfolk Government Operations Emissions by Sector....1-3
1-2 2010 Norfolk Community CO_2e Emissions by Source....1-2
2-1 Emission Sources and Associated Scopes....2-8
2-1 Emission Sources and Associated Scopes....2-8
3-1 2010 City of Norfolk Government Operations Emissions by Sector....3-9
3-2 2010 City of Norfolk Government Operations Emissions by Scope....3-11
3-3 2010 City of Norfolk Government Operations Emissions by Source....3-12
3-4 Buildings and Facilities Summary of CO_2e Emissions by Source....3-14
4-1 2012 Norfolk Community CO_2e Emissions by Sector....4-21
4-2 2012 Norfolk Community CO_2e Emissions by Source....4-22
4-3 Norfolk Southern Railway Map....4-25
4-4 ORF Gates, Runway and Taxiway Configuration....4-27
4-5 EPA 2010 MSW Waste Characterization....4-28

Acronyms and Abbreviations

ACRP	Airport Cooperative Research Program
APU	Auxiliary Power Units
CACP	Clean Air and Climate Protection
CH_4	Methane
CO_2e	Carbon Dioxide Equivalent
CO_2	Carbon Dioxide
EDMS	Emissions and Dispersion Modeling System
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FOD	First Order Decay
GHG	Green House Gas
GSE	Ground Support Equipment
GWP	Global Warming Potential
HFC	Hydroflurocarbons
HRSD	Hampton Roads Sanitation District
HRT	Hampton Roads Transit
IPCC	Intergovernmental Panel on Climate Change
LFG	Landfill Gas
LGOP	Local Government Operations Protocol
LTO	Landing and Take Off
MMSCFD	million standard cubic feet
MSW	Municipal Solid Waste
NSPS	New Source Performance Standards
N_2O	Nitrous Oxide
ODS	Ozone Depleting Substance
PFC	Perflurocarbons
RDF	Refuse Derived Fuel
SPSA	Southeastern Public Service Authority
SF_6	Sulfur Hexafluoride

Acknowledgements

Compiling a greenhouse gas inventory requires an enormous amount of information from a wide variety of sources. The Old Dominion inventory team and the City of Norfolk would like to extend special thanks to the individuals and organizations that provided the information that made this inventory possible.

Executive Summary

The overall aim of this inventory is to provide the City of Norfolk with a baseline from which strategies for future reduction of greenhouse gas (GHG) emissions can be developed. This is accomplished by providing an emissions baseline and a complete understanding of the various sources of emissions and their magnitude.

The benefits of developing a GHG inventory go well beyond helping local governments manage climate risk and promote environmental stewardship. It is also an effective method of addressing inefficiencies within processes and operations. The generation of GHG emissions has real costs associated with it. Identifying operations and processes that can be improved to reduce GHG emissions can ultimately result in utilization of fewer resources and cost savings.

This inventory contains two distinct sections; Government Analysis and Community Analysis. The Government Analysis is composed of ten reporting sectors and represents an in depth account of all emissions associated with operations of the City of Norfolk. The Government Analysis was performed in accordance with the Local Government Operations (LGO) Protocol (ICLEI 2010). This section makes up a small subset of the larger Community Analysis, which includes emissions from all sources within the geographic footprint of the City of Norfolk. The Community analysis was conducted in accordance with the U.S. Community Protocol (ICLEI 2012).

This inventory was conducted based on the best available data and in accordance with the most recent calculation methodologies.

1.1 Government Analysis – Inventory Results

Emissions from the City of Norfolk's operations for the 2010 calendar year totaled 184,832 metric tons of carbon dioxide equivalent (CO_2e). Of the total emissions calculated for the City of Norfolk's operations the Buildings and Facilities sector accounted for 130,209 metric tons CO_2e. The Buildings and Facilities sector was the largest source of emissions accounting for 70 percent of the City's total emissions. Streetlights and traffic signals accounted for 7 percent of total government operations emissions, with 13,350 metric tons CO_2e. Water delivery facilities also accounted for 7 percent of the total government operations emissions, with 13,446 metric tons CO_2e. Airport facilities accounted for 10 percent of emissions with 17,923 metric tons CO_2e. The City of Norfolk's vehicle fleet accounted for 3 percent of total government operations emissions, with 4,829 metric tons CO_2e[1]. Emissions from other processes & fugitive sources accounted for 3 percent of total government operations emissions, with 5,075 metric tons CO_2e.

[1] Note: Fleet data was only available for Norfolk Public Schools. Emission calculations are not representative of the entire City's vehicle fleet

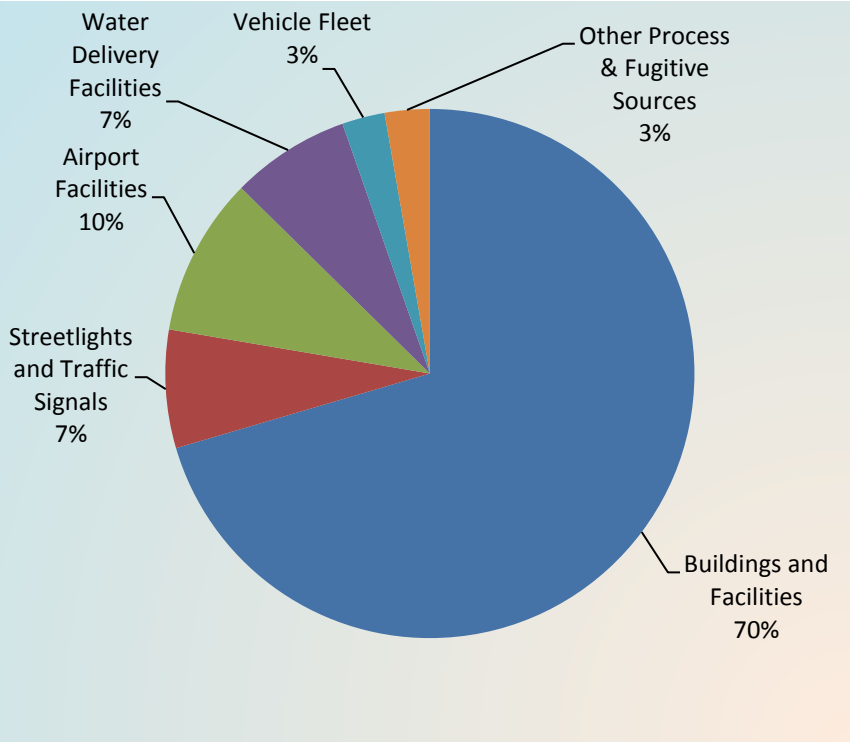


Figure 1.1: 2010 City of Norfolk Government Operations Emissions by Sector

Emissions from wastewater facilities, transit, port facilities and solid facilities are not included in the City of Norfolk's government operations inventory due to organizational boundary determinations (see Section 2.2). With the exception of port facilities, emissions from these sectors were calculated and are included in the community analysis.

Table 1.1:
2010 City of Norfolk Government Operations Emissions by Sector

Sector	Sector Total (metric tons CO_2e)	Percentage of Total
Buildings and Facilities	130,205	70%
Streetlights and Traffic Signals	13,300	7%
Airport Facilities	17,923	10%
Water Delivery Facilities	13,446	7%
Vehicle Fleet	4,829	3%
Other Process & Fugitive Sources	5,075	3%
Total	**184,788**	**100**

1.2 Community Analysis – Inventory Results

The second section contained in this inventory report is the Community Analysis. The Community analysis includes the required five basic emissions generating activities; electricity use, fuel consumption in stationary combustion, on-road passenger and freight motor vehicle travel, energy use in water and wastewater treatment and distribution and generation of solid waste. These emission generating activities are reported in five distinct sectors as shown in **Figure 1.2**. Emissions from transportation within the community accounted for the largest percentage of emissions (41 percent) with 1,528,035 metric tons CO_2e. The Commercial sector accounted for 1,351,914 metric tons CO_2e, or 36 percent of total community emissions. The commercial sector includes emissions from government and wastewater facilities as well as other commercial sources. Emissions from the industrial sector totaled 135,972 metric tons CO_2e. The industrial sector is relatively small in Norfolk community and accounted for only four percent of total community emissions. Emissions from Municipal Solid Waste (MSW) totaled 37,491 metric tons CO_2e and accounted for only one percent of total community emissions.

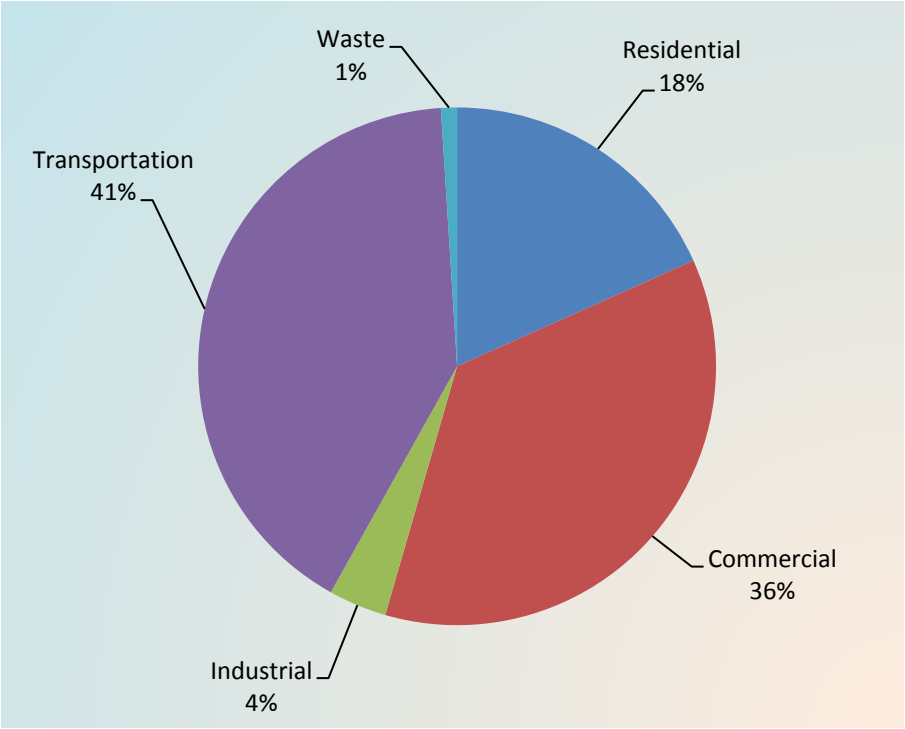


Figure 1.2: 2010 Norfolk Community CO_2e Emissions by Source

Table 1.2:
2010 Norfolk Community CO_2e Emissions by Source

Sector	Sector Total CO_2e (metric tons)	Percentage of Total
Residential	684,188	20%
Commercial	1,351,914	39%
Industrial	135,972	4%
Transportation	1,528,035	36%
Waste	37,491	1%
Total	**3,737,600**	**100%**

GHG emissions from the Norfolk Community totaled 3,737,600 metric tons CO_2e during the 2010 calendar year. Emissions from the City of Norfolk operations make up a very small portion of the overall community GHG emissions (approximately 5 percent).

Introduction

2.1 Background

Increasing concern of the effects of anthropogenic global warming has led many local governments to evaluate the Green House Gas (GHG) emissions associated with their operations as well as the larger community. A comprehensive GHG inventory is an important precursor to developing emissions reduction strategies. In May of 2010 the California Air Resources Board partnered with the California Climate Action Registry, ICLEI – Local Governments for Sustainability and The Climate Registry to develop a standard method of GHG reporting, the *Local Government Operations Protocol (LGOP) For the Quantification and reporting of Greenhouse Gas Emissions.* This protocol establishes a standard set of reporting requirements and procedures for municipalities to follow in conducting a GHG inventory.

The first step in completing a GHG inventory is the selection of a baseline year. For the purposes of this GHG inventory the City of Norfolk has selected 2010 as its baseline year, because it is believed to be representative of their standard emissions profile and is a year in which they have the most complete data available.

2.2 Inventory Organizational Boundary

Allocating emissions to the appropriate entity can seem complex, but it is absolutely essential to developing an accurate, reproducible and complete GHG inventory. The organizational boundary of the City of Norfolk was determined according to LGOP recommended method. This approach defines the organizational boundary based upon operational control. The LGOP defines operational control as:

- Wholly owning an operation, facility or source; or
- Having the full authority to introduce and implement operational health, safety and environmental policies.

Under this approach GHG emissions are only attributed to the City of Norfolk if it is established that the City has operational control of the GHG emissions source.

Two distinct sections are included in this inventory; a Government Analysis and a Community Analysis. The Government Analysis only accounts for emissions directly attributable to the City of Norfolk. The Community Analysis accounts for all emissions generated within the geographic footprint of the City of Norfolk. Emissions from electricity generation often occur outside of the community where the electricity is consumed. Despite the physical location of the emission source, emissions from the consumption of electricity are included in the Community Analysis. Emissions that are not captured in the Government Analysis section (due to a lack of operational control) will be included as part of the Community Analysis. Specific methodologies applied in

calculating emissions from each individual sector are described in detail in the appropriate sections of the Community Analysis portion.

According to the LGOP, "A special district is a political subdivision of a state established to provide a single public service (e.g. water supply or sanitation) within a specific geographic area." The Hampton Roads region is somewhat unique in that a number of political subdivisions of the Commonwealth of Virginia have been established to provide a variety of services to the City of Norfolk and throughout the region. Examples include Hampton Roads Transit (HRT), Hampton Roads Sanitation District (HRSD), and Southeastern Public Service Authority (SPSA). These organizations provide essential services to the City of Norfolk as well as many other cities and counties in the Hampton Roads region. By definition local governments do not have operational control over special districts. Therefore the GHG emissions associated with special districts are not attributable to a municipality and are not to be included in the Government Analysis portion of an inventory report. Since portions of the above-mentioned special districts operate within the geographic footprint of the City of Norfolk, GHG emissions from these operations will be captured in the Community Analysis.

2.3 Methodology

This GHG inventory report is divided into two distinct sections; Government Analysis and Community Analysis. In each section the Scope 1 and Scope 2 emissions associated with each reporting sector are calculated and converted to Carbon Dioxide equivalents (CO_2e). This is done within the Clean Air Climate Protection (CACP) software provided by ICLEI. The CACP tool takes reported emissions of GHGs (e.g. CO_2, nitrous oxide N_2O, methane CH_4, various refrigerants including hydroflurocarbons (HFCs) and applies an emission factor convert emissions to CO_2e. The CACP default emission factors were utilized for all inventory calculations. The default emission factors within the CACP software are derived from a number of different sources and may be periodically updated. Appendix G of the LGOP contains a complete list of default emission factors for fuels, GHGs and combustion technologies. In certain cases (Solid Waste and Wastewater sectors) GHG emissions need to be calculated based on operating data before being entered in the CACP software. These calculations were performed within the ICLEI Government Master Data Workbook and are detailed in the appropriate sections of this report.

Electricity generation accounts for one of the largest sources of GHG emissions in any municipality. The CACP software allows the user to specify electricity emission factors that will be utilized in converting kilowatt hours (kWh) to CO_2e. Utility-specific emission factors were not available and instead the EPA's Emission & Generation Resource Integrated Database (eGRID) was utilized. The eGRID database provides regional electricity emission factors which may or may not be as accurate as utility-specific emission factors (see Appendix B).

2.4 Greenhouse Gas Reporting

Emissions of all six GHGs as identified by the Kyoto Protocol, shown below in Table 2.1, are accounted for in this inventory. Emissions from each specific GHG are converted to metric tons of equivalent CO_2 (CO_2e) to allow for easy comparison of emissions across different sectors and from different sources. It is important to note that there are many different gases that are categorized as perflurocarbons (PFCs) and HFCs.

Table 2.1:
GHGs regulated under the Kyoto Protocol

Carbon Dioxide(CO_2)	Nitrous Oxide (N_2O)	Perflurocarbons (PFCs)
Methane (CH_4)	Hydrofluorocarbons (HFCs)	Sulfur Hexafluoride (SF_6)

Each GHG identified Table 2.1 above has a Global Warming Potential (GWP) factor associated with it. GWP factors are calculated based on the ability of each gas to trap heat within the atmosphere relative to heat trapping ability of Carbon Dioxide. The IPCC publishes updated GWP factors in each of its successive assessment reports; however according to the LGOP, the values published in the Second Assessment Report from the IPCC are still the international standard used in GHG reporting.

Emissions captured as part of the Government Analysis are categorized into three different "scopes" to separately account for direct and indirect emissions. This approach improves the transparency and utility of the Government emissions inventory. **Figure 2.1** below shows examples of emissions sources for each scope. According to the LGOP, emissions are categorized as follows:

Scope 1: All direct GHG emissions (with the exception of direct CO_2 emissions from biogenic sources)

Scope 2: Indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating or cooling.

Scope 3: All other indirect emissions not covered in Scope 2, such as emissions resulting from the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity (e.g. employee commuting and business travel), outsourced activities, waste disposal, etc.

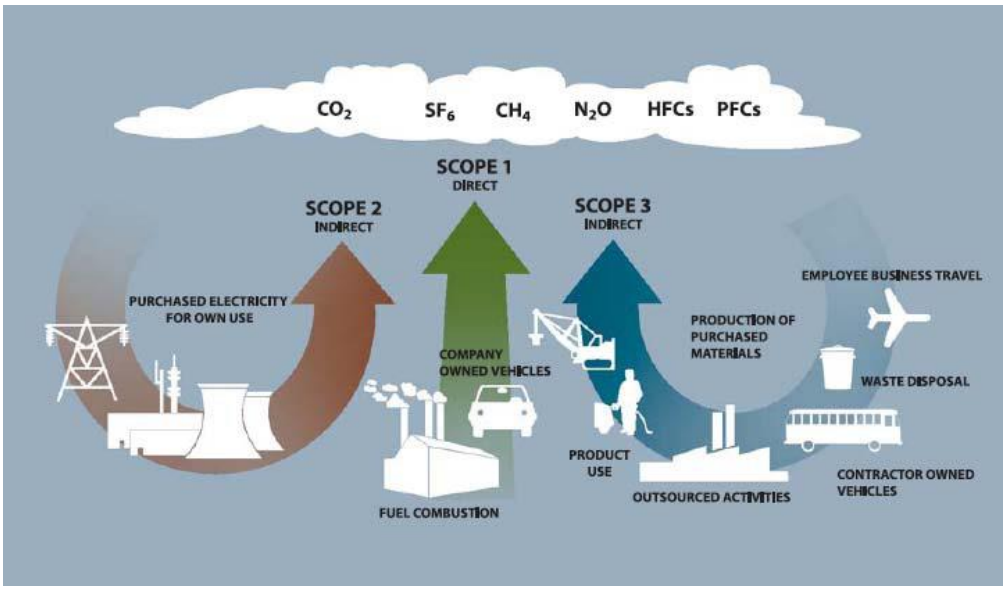


Figure 2.1: Emission Sources and Associated Scopes
Source: WRI/WBCSD GHG Protocol Corporate Standard, Chapter 4 (2004

Figure 2.1 above shows a diagram of emission sources and their related scope. It is a requirement of the LGOP that local governments report all Scope 1 and 2 emissions. The LGOP encourages municipal governments to report Scope 3 emissions such as those from special districts. However, reporting Scope 3 emissions is optional and is included in this inventory only where data was available.

Emissions captured as part of the Community Analysis are not categorized into individual Scopes like emissions in the Government Analysis. Instead emissions are grouped by sector; Industrial, Commercial, Residential, Transportation and Waste. These sectors report electricity use by the community, fuel consumption, on-road passenger and freight motor vehicle travel and end-of-life emissions from solid waste.

Government Analysis

3.1 Summary by Sector

Emissions from the City of Norfolk's operations for the 2010 calendar year totaled 184,778 metric tons of carbon CO_2e. Of the total emissions calculated for the City of Norfolk's operations the Buildings and Facilities sector accounted for 130,205 metric tons CO_2e. The Buildings and Facilities sector was the largest source of emissions accounting for 70 percent of the City's total emissions. Streetlights and traffic signals accounted for 7 percent of total government operations emissions, with 13,300 metric tons CO_2e. Water delivery facilities also accounted for 7 percent of the total government operations emissions, with 13,446 metric tons CO_2e. Airport Facilities accounted for 10 percent of emissions with 17,923 metric tons CO_2e. Emissions associated with Airport Facilities only include Scope 1 emissions from stationary combustion and Scope 2 emissions from purchased electricity. Emissions generated from air travel are not included in the total emissions for Airport Facilities. They are instead accounted for in the Community Analysis under Section 4.3.4: Transportation. The City of Norfolk's vehicle fleet accounted for 3 percent of total government operations emissions, with 4,829 metric tons CO_2e[2]. Data encompassing the entire fleet of vehicles owned and operated by the City of Norfolk was not available. Vehicle emissions were only calculated for Norfolk Public Schools fleet vehicles. Emissions from the entire City of Norfolk fleet are most likely higher than the reported value.

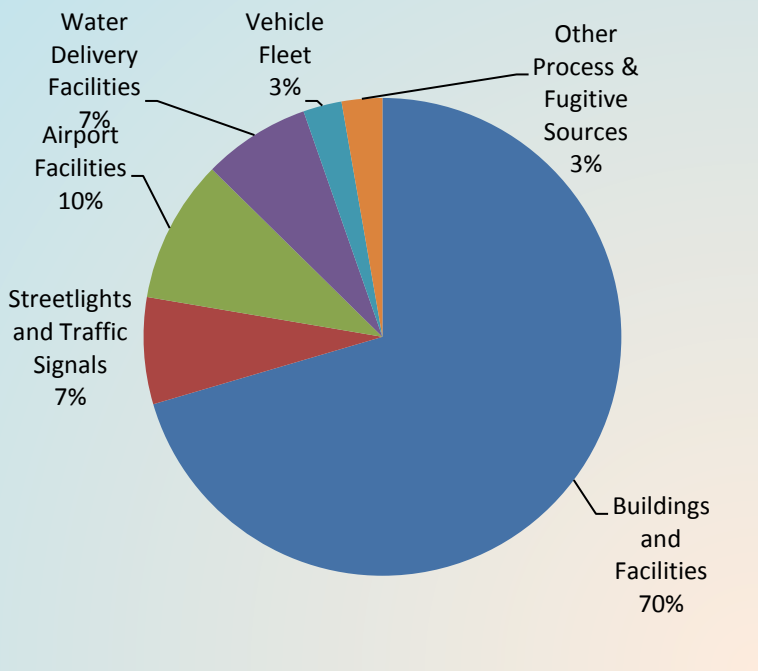


Figure 3.1: 2010 City of Norfolk Government Operations Emissions by Sector

[2] Note: Fleet data was only available for Norfolk Public Schools. Emission calculations are not representative of the entire City's vehicle fleet

Emissions from other processes & fugitive sources accounted for 5,075 metric tons CO_2e or 3 percent of total government operations emissions. Emissions from wastewater facilities, transit, port facilities and solid facilities are not included in the City of Norfolk's government operations inventory due to organizational boundary determinations (see Section 2.2). With the exception of port facilities, emissions from these sectors were calculated and are included in the community analysis.

Table 3.1:
2010 City of Norfolk Government Operations Emissions by Sector

Sector	Sector Total (metric tons CO_2e)	Percentage of Total
Buildings and Facilities	130,205	70%
Streetlights and Traffic Signals	13,300	7%
Airport Facilities	17,923	10%
Water Delivery Facilities	13,446	7%
Vehicle Fleet	4,829	3%
Other Process & Fugitive Sources	5,075	3%
Wastewater Treatment*	(13,777)	0%
Solid waste*	(37,491)	0%
Total	**184,778 (236,046)**	**100**

*Scope 3 Emissions not included in total Government Operations Emissions Summary

3.2 Summary by Source and Scope

In addition to reporting emissions by sector reporting emissions by source and by scope is beneficial to fully characterizing all emissions reported in an inventory. As shown in **Figure 3.2**, Scope 2 emissions from purchased electricity accounted for the highest percentage (67 percent) of all City government emissions. Scope 1 emissions include emissions from stationary combustion, mobile combustion and fugitive emissions. These emissions are due to consumption of natural gas, fuel for City of Norfolk vehicles and fugitive emissions from refrigerants. Scope 1 emissions were found to account for 11 percent of Government emissions. Scope 3 emissions are not required to be reported and are only included here where data was available. They include emissions from wastewater treatment facilities and processes and from solid waste disposal. Scope 3 emissions accounted for 23 percent of total government emissions.

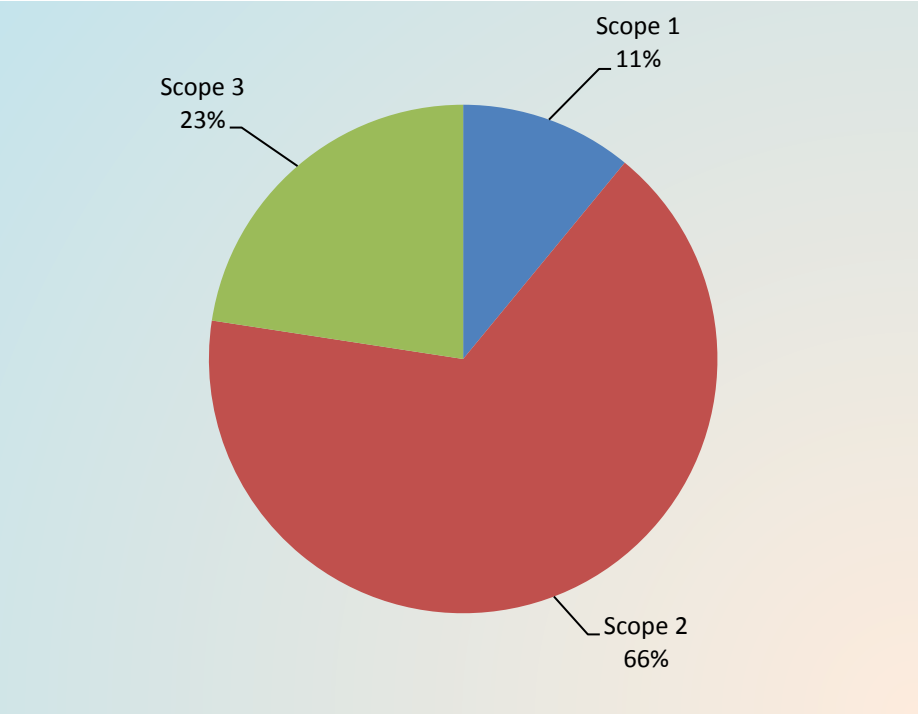


Figure 3.2: 2010 City of Norfolk Government Operations Emissions by Scope

Table 3.2:
2010 City of Norfolk Government Operations Emissions by Scope

	Total CO_2e (metric tons)
Scope 1	24,906
Scope 2	150,886
Scope3	51,268
Total	**236,046**

Understanding emission sources is important to developing relevant emission reduction strategies. The majority of emissions generated by the City of Norfolk in the calendar year 2010 were due to electricity consumption. As shown in **Figure 3.2** electricity consumption accounted for 82 percent of total emissions for the City of Norfolk. Emissions from stationary combustion of natural gas and electricity consumption are associated with the buildings and facilities sector and it therefore makes sense that they would constitute the two largest sources of emissions.

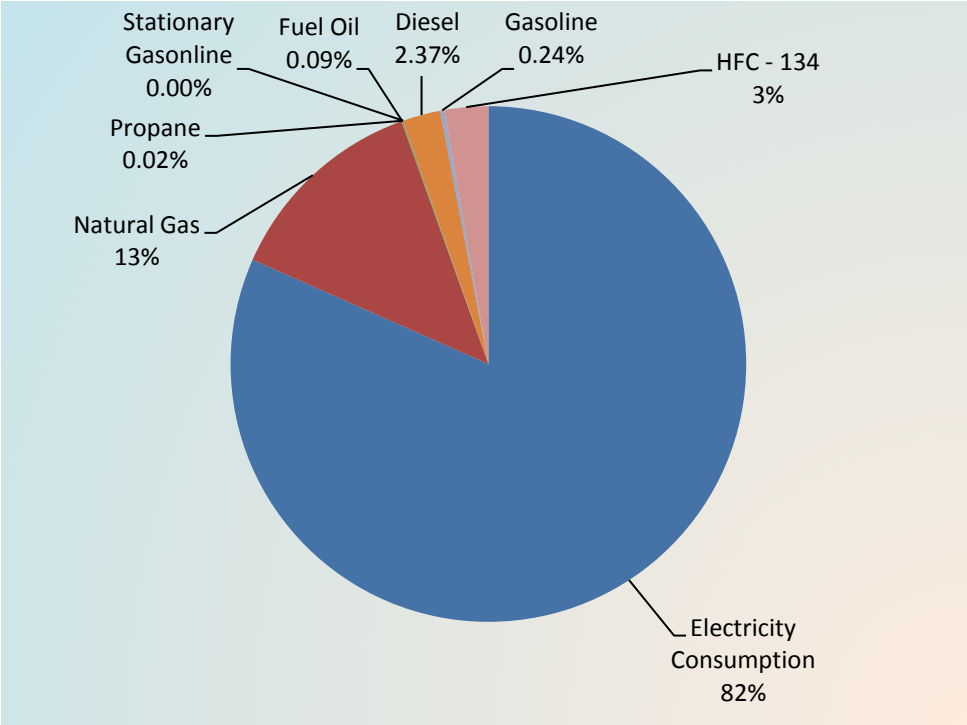


Figure 3.2: 2010 City of Norfolk Government Operations Emissions by Source

Table 3.3:
2010 City of Norfolk Government Operations Emissions by Source

	Total CO_2e (metric tons)
Electricity Consumption	150,836
Natural Gas	23,830
Fuel Oil	168
Propane	38
Stationary Gasoline	2
Diesel	4,383
Gasoline	446
HFC - 134	5,075
Total	**184,778**

3.3 Detailed Sector Analyses

3.3.1 Buildings and Facilities

Heating, cooling, lighting and operating the City of Norfolk's buildings and facilities requires a great deal of energy. Significant portions of the GHG emissions of the City of Norfolk are attributable to operating and maintaining this infrastructure. The City of Norfolk operates a diverse range of facilities including but not limited to; fire stations, libraries, schools, police stations, recreation centers and entertainment venues. Buildings and Facilities produce GHGs primarily through the consumption of electricity, natural gas and heating oil.

Dominion Power provided a summary of 2010 electricity consumption for all City of Norfolk accounts. In 2010, buildings and facilities operated by the City of Norfolk consumed 215 million kWh of electricity. Consumption of electricity produced 90% of all GHG emissions associated with buildings and facilities. Scope 2 emissions from electricity consumption accounted for 109,628 metric tons CO_2e.

Natural gas and No. 2 fuel oil consumption data was obtained from the City of Norfolk Energy Audits conducted by CEGG of Virginia Beach in May, 2011 and from the Norfolk Public Schools Global Building Use Cost by Utility Type. In 2010, buildings and facilities operated by the City of Norfolk consumed 2,167,983 therms of natural gas. Consumption of natural gas accounted for 10% of all GHG emissions associated with buildings and facilities. Scope 1 emissions from stationary combustion of natural gas contributed for 20,574 metric tons CO_2e. Emissions from the stationary combustion of No. 2 fuel oil accounted for 3 metric tons of CO_2e emissions.

Total emissions from Buildings and facilities for the 2010 calendar year were calculated to be 130,209 metric tons CO_2e.

Norfolk Public school facilities account for the largest percentage of GHG emissions associated with the Buildings and Facilities sector for the City of Norfolk (36% of total emissions). As is common for many local governments, school facilities constitute the largest number of buildings by department and therefore account for the largest percentage of emissions. **Figure 3.1** provides a summary of CO_2e emissions calculated for various departments as well as individual facilities operated by the City of Norfolk.

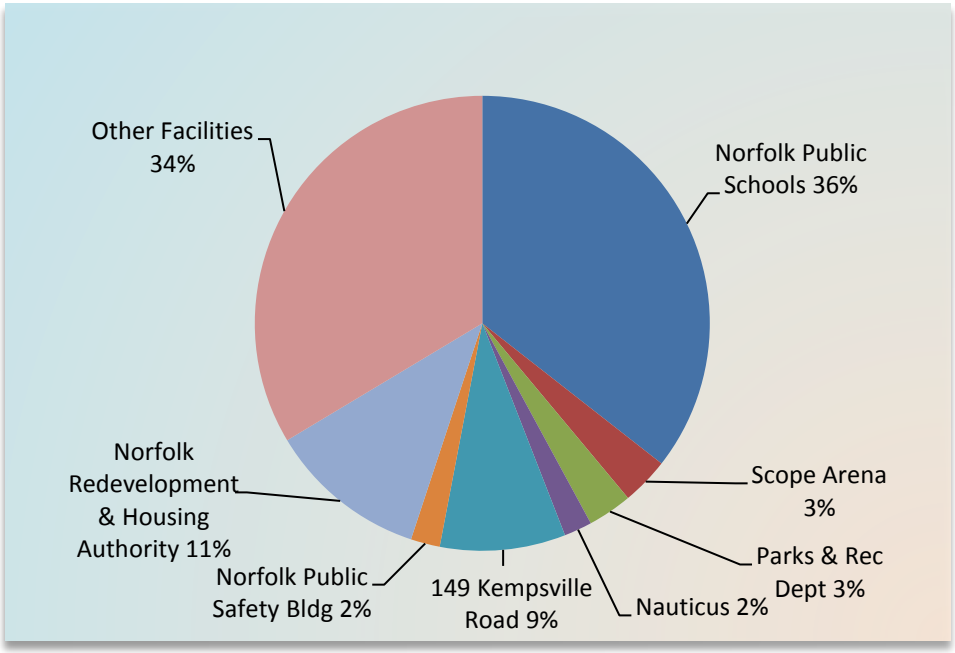


Figure 3.3: Buildings & Facilities Summary of CO_2e Emissions by Source

Fugitive emissions from refrigeration and fire retardant equipment other common sources of emissions associated with buildings and facilities. These emissions are accounted for separately in Section **3.3.10 Other Process Fugitive & Mobile Sources** and are not part of the total emissions accounted for in the Buildings and Facilities sector.

3.3.2 Streetlights and Traffic Signals

The City of Norfolk operates and maintains a variety of public lighting including; streetlights, traffic signals and control boxes and other outdoor lighting. Electricity consumed in the operation of the City's lighting infrastructure is a significant source of GHG emissions. Electricity consumption data was provided by Dominion Power for all public lighting owned and operated by the City of Norfolk.

Table 3.4:
Energy use and Emissions from Public Lighting

Source	GHG Emissions (metric tons CO_2e)	% Emissions of all Lighting	Electricity Use (kWh)
Streetlights	12,021	90	23,473,776
Traffic Signals and Controllers	1,320	9.9	2,577,845
Other Outdoor Lighting	9	0.1	17,567
TOTAL	13,350	100%	26,069,188

As shown in **Table 3.1** above, the City of Norfolk purchased 26 million kilowatt hours of electricity to power all public lighting in 2010. The CACP software was utilized to calculate the total CO_2e for all public lighting. Scope 2

emissions due to consumption of electricity by public lighting were calculated to be 13,350 metric tons CO_2e for 2010.

3.3.3 Port Facilities

Norfolk is home to one of the leading ocean container terminal complexes on the East Coast, the Port of Virginia. The Port of Virginia is committed to environmental stewardship and has undertaken programs targeting reduction of emissions, energy conservation and wetland restoration. It is currently the only major port on the East coast to be ISO 14001 Certified for Environmental Management.

The Port of Virginia is governed by a Board of Commissioners, consisting of the Virginia State Treasurer and eleven members appointed by the Governor of Virginia, and four Directors. The City of Norfolk does not have operational control of the Port of Virginia. Therefore emissions associated with the Port's operation are not included in this sector of Government Analysis.

The Port of Virginia is located within the boundaries of the City of Norfolk and emissions associated with the operations of the Port of Virginia are included in the Community analysis.

3.3.4 Airport Facilities

The Norfolk International Airport located northeast of downtown Norfolk serves the Hampton Roads region. The Norfolk Airport Authority, a political subdivision of the Commonwealth of Virginia is responsible for operations of the Airport. The Authority is classified as an independent autonomous agency of the City of Norfolk. However, the Authority is governed by a nine member Board of Commissioners that is appointed by the Norfolk City Council. This implies that the City of Norfolk has some level of oversight of the Board and establishes that the City has operational control of airport facilities. Emissions produced from the operation of Airport facilities (Stationary Sources) are reported in this section.

The City of Norfolk does not have operational control over tenant activities including aircraft operations, Auxiliary Power Units (APU) and Ground Support Equipment (GSE). Emissions associated with these sources are not included in this section but are reported in the Community Analysis.

3.3.4.1 Emissions Calculation Methodology

A GHG inventory for the Norfolk International Airport was prepared utilizing the guidelines presented in the Airport Cooperative Research Program (ACRP) Report 11 *Guidebook for Preparing Airport Greenhouse Gas Inventories*[3] (Kim 2009). Emissions from the following sources were calculated according to the methodology presented in the ACRP Report: Aircraft, APU,GSE and Stationary Sources.

---

[3] ACRP Report 11 is available at: http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf (12-2012)

Emissions from stationary sources were calculated utilizing electricity consumption data provided by Dominion Power and fuel consumption data provided by the Norfolk International Airport. In 2010 buildings and facilities associated with the Norfolk International Airport utilized 28 million kWh of electricity. Scope 2 emissions from consumption of electricity produced 81% of all GHG emissions associated with the Norfolk International Airport, accounting for 14,462 metric tons CO_2e. Emissions from consumption of natural gas, propane, diesel fuel, and No.2 fuel oil were calculated from consumption data provided by the Norfolk International Airport. Scope 1 emissions from consumption of these sources produced 19% of all GHG emissions associated with the Norfolk International Airport, accounting for 3,461 metric tons CO_2e. Total emissions from Norfolk International Airport stationary sources in 2010 were 17,923 metric tons CO_2e.

3.3.5 Water Delivery Facilities

The Norfolk Department of Utilities is responsible for providing drinking water to over 850,000 people in Norfolk, Virginia Beach, portions of Chesapeake and various U.S. Naval facilities. Water is supplied by eight reservoirs owned by the City including; Western Branch, Lake Prince and Lake Prince Transfer to Western Branch, Burnt Mills and Burnt Mills Transfer to Western Branch, Lake Wright, Lake Smith and Lake Gaston. Additional sources of raw water include the Blackwater and Nottoway Rivers along with four deep wells located in Suffolk. Raw water is pumped to either the 37th Street Water Treatment Plant or the Moores Bridges Water Treatment Plant. The City uses seven ground and two elevated tanks along with two underground clear wells for storing treated drinking water before pumping into distribution lines on demand.

Electricity consumption and combustion of fuels such as natural gas are the sources of GHG emissions associated with water delivery facilities. Data on electricity consumption was provided by Dominion Power as part of the summary of the City of Norfolk's metered accounts. Pump stations, treatment plants and other facilities associated with water delivery for the City of Norfolk consumed 26 million kWh in 2010. This was entered into the CACP software as Scope 2 emissions (purchased electricity). The CACP software calculated the equivalent CO_2 emissions to be 13,446 metric tons.

3.3.6 Wastewater Facilities

Wastewater facilities serving the City of Norfolk are owned and operated by Hampton Roads Sanitation District (HRSD). HRSD falls into the category of Special Districts as outlined in the LGOP. According to the LGOP, "A Special District is a political subdivision of a state established to provide a single public service within a specific geographic area." HRSD is governed by an eight-member board that sets policy and makes decisions on budget matters. Each board member is from one of the communities that HRSD serves and is appointed by the governor of Virginia to serve a four-year term. As a Special District, the City of Norfolk does not have operational control over HRSD. Emissions associated with wastewater treatment and facilities are therefore not attributable to the City of Norfolk

and are not captured under the Government Analysis. All emissions associated with wastewater treatment facilities are reported in this section Scope 3.

3.3.6.1 Emissions Calculation Methodology

As in many industrial facilities, emissions associated with Wastewater Treatment Plants (WWTPs) are generated from consumption of electricity and natural gas. WWTPs are unique in that emissions from the wastewater treatment process must also be accounted for. Electricity and natural gas consumption data was obtained from each of the three HRSD plants that serve the City of Norfolk in some capacity. **Table 2.3** below shows the electricity and natural gas consumption reported by each plant as well as the percentage of flow each plant receives that originates from the City of Norfolk. The percent flow data obtained from HRSD was utilized in allocating emissions, (i.e. because 62% of the VIP plants flow originates from Norfolk, only 62% of all emissions from the VIP plant will be allocated to Norfolk).

Table 3.5:
2010 HRSD WWTP Emissions Summary

	Process Emissions		Electricity		Natural Gas		Gasoline	
WWTP	**(N_2O)**	**(CO_2e)**	**(kWh)**	**(CO_2e)**	**(Therms)**	**(CO_2e)**	**(gal)**	**(CO_2e)**
ARMY Base	3.3648	1,043	7,979,200	4,071	2,094	11	11,150	99
Virginia Initiative Plant	2.3769	737	12,954,083	6,609	172039	914	--	--
Chesapeake-Elizabeth	0.628	195	191,400	98	3.2	0	--	--
Total	***6.3697***	***1,975***	***21,124,683***	***10,778***	***174,136***	***925***	***11,150***	***99***

Note: Dashes indicate missing data

The ICLEI Government Master Data Workbook was utilized in determining the amount of N_2O generated during the wastewater treatment process. This Microsoft Excel based tool includes an easy to use spreadsheet employing the equations for calculating process N_2O emissions from centralized wastewater treatment presented in the LGOP. The required inputs were calculated as follows;

- The average total nitrogen discharged by each WWTP (kg N/day) in 2010 was calculated from information provided by HRSD. This value was scaled proportional according to the percentage of flow originating from the City of Norfolk.
- The total domestic population served by each treatment plant was calculated based on each plant's average flow and the percentage of that flow that originated from the City of Norfolk. The U.S. census bureau reported the total domestic population of Norfolk to be 242,803 in 2010.

Table 3.6:
Calculation of Population Served for Each WWTP

WWTP	Ave Flow	% Flow From Norfolk	Ave Flow from Norfolk	% of Total Flow from Norfolk	Population Served

AB	11.12	100.00%	11.12	34.31%	83,315
VIP	31.22	62.00%	19.36	59.73%	145,024
CE	17.55	11.00%	1.93	5.96%	14,464
Total			**32.41**		**242,803**

The metric tons of N_2O calculated from process emissions at all three wastewater treatment plants was entered into the CACP software to determine the equivalent CO_2 production. Total Scope 1 emissions from wastewater treatment processes were calculated to be 1,975 metric tons CO_2e. Emissions associated with purchased electricity and stationary combustion of natural gas and gasoline were calculated to be 10,778, 925 and 99 metric tons of CO_2e respectively. Total emissions from wastewater treatment for facilities serving the City of Norfolk were calculated to be 13,777 metric tons CO_2e.

3.3.7 Solid Waste Facilities

Waste collected by the City of Norfolk's municipal haulers is brought to the Southeastern Public Service Authority's (SPSA) Norfolk Transfer Station. The SPSA Norfolk Transfer station also receives solid waste from individual Norfolk residents as well as private waste haulers. At the Norfolk Transfer Station waste is sorted into combustible and non-combustible waste. Combustible waste is delivered to the Wheelabrator Technologies Refuse-Derived Fuel Plant (RDF) where it is burned to generate electricity and steam. Emissions associated with the RDF plant are captured under the Community Analysis section and are reported here only as Scope 3. Non-combustible waste is transferred to the SPSA Regional Landfill located in Suffolk VA. The SPSA Regional Landfill accepts municipal solid waste from the Southern Hampton Roads region which includes a number of local governments.

SPSA falls into the category of Special Districts as outlined in the LGOP. The City of Norfolk does not have operational control over the SPSA Regional Landfill or any other solid waste disposal facilities. Fugitive CH_4 emissions from the SPSA Regional Landfill and emissions from controlled incineration at the RDF plant that are attributable to municipal solid waste generated by the City of Norfolk are reported in this section as Scope 3 emissions. 2010 GHG emissions from the SPSA landfill were determined to be 8,450 metric tons CO_2e. Emissions from controlled incineration of waste at the RDF plant were calculated to be 29,041 metric tons CO_2e.

Emissions associated with municipal solid waste generated by the City of Norfolk in 2010 are captured in the Community Analysis under **Section 4.3.5**. The methodology involved in calculating emissions for municipal solid waste is discussed in detail in the Community Analysis.

3.3.8 Vehicle Fleet

The City of Norfolk depends on a diverse fleet of vehicles to provide essential services to the community. The LGO Protocol requires that emissions of CO_2, N_2O and CH_4 from fleet vehicles are accounted for in this sector. Emissions from fleet vehicles depend on a number of factors including; fuel consumption, the type of fuel the vehicle utilizes and the emission control technology the vehicle is equipped with. Fuel consumption varies slightly by vehicle age and type, with newer vehicles tending to be more efficient. N_2O and CH_4 emissions are heavily dependent on the emission control technology employed by individual vehicles. Emission control technology has changed considerably over the years and as a result N_2O and CH_4 emissions depend heavily on vehicle type and model year. For this reason N_2O and CH_4 emissions are calculated separately using different methodology.

In order to calculate N_2O and CH_4 fleet data for the City of Norfolk was sorted by fuel type, vehicle type and model year. Vehicle miles traveled (VMT) data for each model year was entered into the CACP software under the appropriate fuel and vehicle type. In 2010, fleet emissions of N_2O and CH_4 totaled 17 metric tons of CO_2e.

CO_2 emissions generated by vehicles are dependent on fuel consumption and are calculated separately from emissions of N_2O and CH_4. Direct fuel consumption data was not available so the ICLEI Government Master Data Workbook was used to estimate fuel consumption. Average fuel efficiency estimates based on fuel and vehicle type as well as vehicle year. Fuel efficiency estimates for passenger vehicles and light trucks were taken from the US Department of Transportation Bureau of Transportation Statistics. Fuel efficiency estimates for heavy duty diesel and gasoline vehicles were obtained from U.S. Department of Energy, Energy Information Administration[4]. Fuel consumption data was entered into the CACP software under the appropriate vehicle type. 2010 CO_2 emissions from the City of Norfolk fleet were found total 4,812 metric tons.

A complete inventory of all City of Norfolk fleet vehicles was not available. Due to data limitations only Norfolk Public Schools fleet vehicles are included in the above analysis.

3.3.9 Transit Fleet

Hampton Roads Transit (HRT) provides buss, rail and ferry services within the City of Norfolk and throughout the Hampton Roads region. HRT is a special district within the Hampton Roads area and the City of Norfolk does not possess operational control. Therefore emissions associated with transit within the City of Norfolk are not included in the Government Analysis. Emissions associated with transit within the City of Norfolk are instead reported under Transportation in the Community Analysis section of this report.

---

4 Source: *2010 Annual Energy Outlook,* Table 67 http://www.eia.gov/oiaf/aeo/tablebrowser/

3.3.10 Other Process Fugitive & Mobile Sources

Hydrofluorocarbons (HFCs) are now commonly used as replacements for Chlorofluorocarbons (CFCs) because unlike CFCs they do not deplete the ozone layer. These compounds are commonly used as refrigerants in building and vehicle cooling systems as well as in fire suppression equipment. The release of even small amounts of HFCs can equate to significant emissions measured as CO_2e. This is due to the fact that HFCs have extremely high global warming potentials (GWP) ranging from 93 to 12,100[5].

3.3.10.1 Emissions Calculation Methodology

Fugitive emissions from process equipment are classified as Scope 1 emissions. The preferred method for estimating CO_2e from fugitive emissions is a simple mass balance approach. This approach requires knowledge of quantity and type of refrigerant used in servicing City owned equipment. It is assumed that the mass of refrigerant required to refill chillers, air conditioning and other units is equal to the mass of refrigerant that has leaked. Data on the mass of refrigerant replaced in currently operating equipment was not available. The City of Norfolk contracts out the maintenance responsibilities for its equipment and places the burden of providing all refrigerant on their vendor encouraging them to prevent and eliminate leaks.

Due to the lack of available data, the Alternative Method provided in the ICLEI Government Master Data Workbook was utilized to calculate the total fugitive emissions. The alternative method allows for selection of a range of full charge capacities (kg of refrigerant) and operating emissions factors (capacity/year) based on the type of equipment employed. The full charge capacity of existing equipment was not known. Therefore in accordance with the alternative method guidelines the high end of the range was used. This is a potential source of error as the actual full charge capacity of a piece of equipment may be lower than what was utilized in calculating the total annual fugitive emissions. According to the information provided by the City of Norfolk the majority of equipment owned and operated by the City utilizes the refrigerant HFC-134a (R-134a). Some equipment however still utilizes R-22; an ozone depleting substance (ODS) more commonly known as Freon. Though Freon does have a GWP it is not classified as a GHG under the Kyoto Protocol and reporting fugitive emissions is therefore not required (LGOP 2010). 2010 Fugitive emissions from the City of Norfolk's process equipment were calculated to be 5,075 metric tons CO_2e.

[5] EPA Ozone Layer Protection: The GWP is the ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide. http://www.epa.gov/ozone/defns.html

Community Analysis

4.1 Summary by Sector

The Community Analysis includes emissions from four sectors; Residential, Industrial, Commercial, Transportation and Solid Waste. Emissions are reported in separate sectors to provide an overview of the various sources of emissions in the Norfolk community and their relative scale. GHG emissions from the Norfolk Community totaled 3,737,600 metric tons CO_2e in 2010.

As shown in **Figure 4.1** the transportation sector accounted for the highest percentage of total community emissions with 1,528,035 metric tons CO_2e. The transportation sector includes emissions from on-road passenger vehicles (including transit vehicles), freight and air travel. The Commercial sector accounted for 1,351,914 metric tons CO_2e emissions in 2010. As shown in **Figure 4.1** the commercial sector accounted for 36 percent of total community emissions. Emissions from government and university buildings and facilities in the Norfolk community are included in the commercial sector. The industrial sector made up only four percent of total community emissions, accounting for 135,972 metric tons CO_2e emissions in 2010. Emissions from the residential sector totaled 684,188 metric tons of CO_2e and accounted for 18 percent of total community emissions. Emissions from solid waste totaled 37,491 metric tons CO_2e and accounted for only one percent of total community emissions.

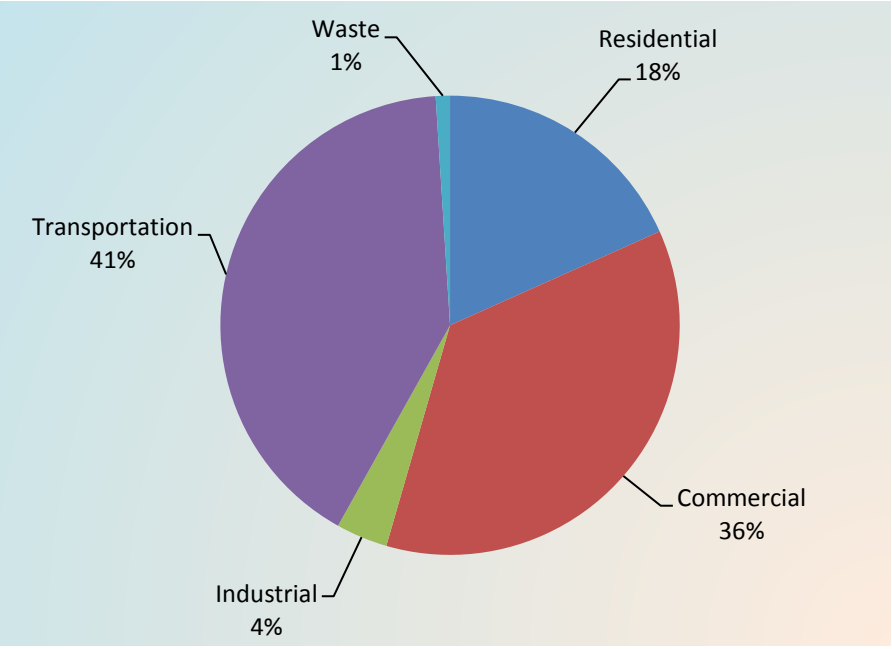


Figure 4.1: 2010 Norfolk Community CO_2e Emissions by Sector

Table 4.1
Community CO_2e Emissions by Sector in 2010

Sector	Sector Total CO_2e (metric tons)	Percentage of Total
Residential	684,188	20%
Commercial	1,351,914	39%
Industrial	135,972	4%
Transportation	1,528,035	36%
Waste	37,491	1%
Total	3,737,600	100%

4.2 Summary by Source

In addition to reporting emissions by specific sector it is also important to consider the source. Emissions are reported here by source to highlight the individual resources that are being utilized by community. As shown in **Figure 4.2** electricity consumption accounted for 48 percent of total community emissions. As is common for most communities, emissions associated with electricity generation are not generated within the geographic footprint of the City of Norfolk. Electricity consumption within any community is a large source of GHG emissions and must be accounted for in any inventory.

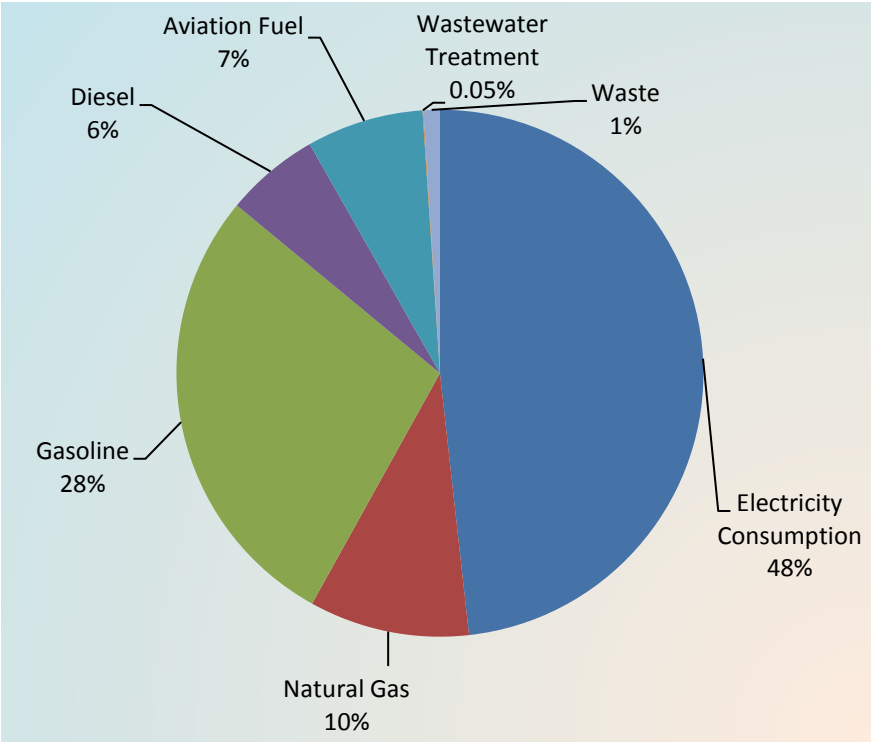


Figure 4.2: 2010 Norfolk Community CO_2e Emissions by Source

Table 4.2:
Community CO_2e Emissions by Source in 2010

Source	Source Total CO_2e (metric tons)	Percentage of Total
Electricity Consumption	1,802,932	48%
Natural Gas	367,167	10%
Gasoline	1,044,009	28%
Diesel	208,180	6%
Aviation Fuel	268,064	7%
Wastewater Treatment	1,975	0.05%
Waste	37,491	1%
Total	**3,737,600**	**100%**

4.3 Detailed Sector Analysis

4.3.1 Residential

Emissions from the residential sector were calculated from electricity consumption data provided by Dominion Power and natural gas consumption data provided by Virginia Natural Gas (VNG).

Total electricity consumption for the Norfolk residential sector was reported to be 1,054 million kWh. Emissions from electricity consumption were calculated to be 538,184 metric tons CO_2e and accounted for 79 percent of all residential emissions. Natural gas consumption for the Norfolk commercial sector was reported to be 2,746.7 billion BTU. Emissions from stationary combustion of natural gas were calculated to be 146,004 metric tons CO_2e and accounted for 21 percent of all emissions from the residential sector.

As shown in **Table 3.1**, residential GHG emissions for the City of Norfolk in 2010 were 684,188 metric tons of CO_2e. Residential emissions made up 18 percent of total emissions for the Norfolk Community. Emissions from other residential sources such as bottled natural gas, propane and fuel oil were not quantified due to a lack of data availability. These are not expected to significant sources of GHG emissions compared to electricity and natural gas consumption.

See Appendix C for example calculations of CO_2e emissions from electricity consumption and stationary combustion of natural gas.

4.3.2 Commercial

Emissions from the commercial sector were calculated from electricity consumption data provided by Dominion Power and natural gas consumption data provided by VNG. The natural gas consumption data provided for the commercial sector includes most governmental and university buildings, however some fall under VNG's Industrial rate schedule and are reported in the Industrial sector. Electricity consumption data provided includes

all government operations within the City of Norfolk. Government operations within the City of Norfolk include all local, state and federal facilities and operations.

Wastewater treatment plants electricity and natural gas consumption are included in the aggregated data from Dominion and VNG. Process emissions from wastewater treatment plants serving the Norfolk community were calculated to be 1,975 metric tons CO_2e and are included in the Commercial sector total emissions.

Total electricity consumption for the Norfolk commercial sector was reported to be 2,389 million kWh. Emissions from electricity consumption were calculated to be 1,219,074 metric tons CO_2e and accounted for 90 percent of all commercial emissions. Natural gas consumption for the Norfolk commercial sector was reported to be 2,461.9 billion BTU. Emissions from stationary combustion of natural gas were calculated to be 130,865 metric tons CO_2e and accounted for 10 percent of all emissions from the commercial sector.

As shown in **Table 3.1**, commercial GHG emissions for the City of Norfolk in 2010 were 1,351,914 metric tons of CO_2e. Commercial emissions made up 36 percent of total emissions for the City of Norfolk.

At the time of writing this report, the Port of Virginia was in the process of conducting a GHG inventory. Port emissions due to electricity and natural gas consumption are aggregated with the data provided by Dominion and VNG; however other emissions from the Port Virginia's operations are not captured in this inventory report but will be included as an addendum when data becomes available.

4.3.3 Industrial

Emissions from the industrial sector were calculated from electricity consumption data provided by Dominion Power and natural gas consumption data provided by Virginia Natural Gas.

Total electricity consumption for the Norfolk industrial sector was reported to be 89,521,856 million kWh. Emissions from electricity consumption were calculated to be 45,674 metric tons CO_2e and accounted for 34 percent of all industrial emissions. Natural gas consumption for the Norfolk industrial sector was reported to be 1,701.4 billion BTU. Emissions from stationary combustion of natural gas were calculated to be 90,298 metric tons CO_2e and accounted for 66 percent of all emissions from the industrial sector.

As shown in **Table 3.1**, industrial GHG emissions for the City of Norfolk in 2010 were 135,972 metric tons of CO_2e. Industrial emissions made up 4 percent of total emissions for the Norfolk community.

4.3.4 Transportation

4.3.4.1 On-road Vehicles

The transportation sector comprises the movement of people and freight by road, air, rail or water and is one of the largest contributors of GHG emissions in most communities. Emissions from on-road vehicles (passenger vehicles as well as heavy duty trucks and buses) were calculated using the CACP Software. Vehicle Miles Traveled (VMT) data for the City of Norfolk was obtained from the Virginia Department of Transportation (VDOT). VMT for

the City of Norfolk totaled 2,145 (million miles) in 2010. This total includes primary roads, secondary roads and interstates. The CACP software includes a Transport Assistant tool that uses state averages to assign the VMT by vehicle category and model year and fuel type. Transportation in the City of Norfolk was found to account for 1,252,189 metric tons of CO_2e emissions in 2010.

4.3.4.2 Rail

Rail is an extremely efficient method of transporting people and goods long distances. A single train is capable of moving the same amount of freight as two hundred and eighty trucks. In addition trains are on average four times more fuel efficient than trucks (EPA 2012). Norfolk Southern operates freight rail service within the City of Norfolk. The Norfolk Southern Sustainability report calculates that companywide Scope 1 and Scope 2 emissions of CO_2e generated in 2010 were 5.2 Million tons. These emissions account for all Norfolk Southern operations including; approximately 20,000 route miles in 22 states. While the Norfolk Sothern's corporate headquarters are located within the City of Norfolk, the vast majority of these reported emissions are generated by business operations outside of the City of Norfolk boundaries.

Figure 4.3: Norfolk Southern Railway Map
Source: Norfolk Southern website
http://www.nscorp.com/nscportal/nscorp/map.html

The emission calculation method described in the US Community Protocol (ICLEI 2012), involves first multiplying the average tonnage of goods moved through the municipality by the average distance traveled through the municipality to obtain the ton-miles of goods moved. Next, fuel consumption rates and emissions factors are applied to calculate the emissions associated with rail operations within the municipality. It was not possible to utilize this method due to a lack of detailed information.

The emissions due to rail operations attributed to the Norfolk Community were calculated utilizing the information available in the Norfolk Southern Sustainability Report. The total miles of rail located within the boundaries of the City of Norfolk were estimated to be 30 miles from Norfolk Southern rail maps. An excerpt of the complete Norfolk Southern railway map is shown in **Figure 4.3**. Based this estimation the City of Norfolk contains approximately 0.15% of all Norfolk Southern rail lines. Data was not available to calculate the ton-miles of goods through the City of Norfolk, but the total GHG emissions associated with all Norfolk Southern operations in 2010 was known to be 5.2 million tons CO_2e (Norfolk Southern 2012 Sustainability Report). By attributing emissions based on percentage of railway miles located within the municipality it was calculated that transportation by rail accounted for 7,800 metric tons of CO_2e emissions in the Norfolk Community.

4.3.4.3 Air travel

Emissions from Aircraft, APUs and GSEs were calculated utilizing the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS) in accordance with the procedures outlined in the ACRP guidebook. Allocating aircraft emissions is complicated by the fact that they are extreme examples of mobile sources. For the sake of consistency and simplicity the ACRP guidebook recommends that the emissions created by each flight be attributed back to the departure airport. This approach is also part of the Intergovernmental Panel on Climate Change (IPCC) international protocol. This approach is preferred because if applied uniformly it prevents double counting emissions from flights. This preferred approach was applied in this inventory.

Fuel consumption data is useful in calculating emissions from flights but relying solely on fuel consumption data can be problematic. Fuel prices vary across the country and airlines take advantage this through a process of tankering fuel. An aircraft may fill its tank up with more fuel than it needs if fuel is more expensive at its destination airport thereby saving on fuel costs. To account for this the total fuel consumption is calculated by applying the following equation:

- *Cruise fuel consumption = (total fuel sales) – (LTO fuel consumption)*

The Norfolk International Airport provided total fuel consumption data. Sales of Jet A in 2010 totaled 27,941,000 gallons.

The Landing and Take Off (LTO) cycle consists of four operating modes[6]; (approach, taxi/idle-in, taxi/idle-out, takeoff and climb out). The LTO fuel consumption was determined through the EDMS software. A basic schedule of daily flight operations was obtained from the Norfolk International Airport. This was utilized in building an estimated yearly schedule for the Norfolk International Airport within EDMS. Gate assignments along with runway and taxiway configurations were determined from airport diagrams provided by Norfolk International airport. **Figure 4.4** shows the diagram of Norfolk International Airport utilized in the EDMS model.

6 As defined by the ARCP guidebook

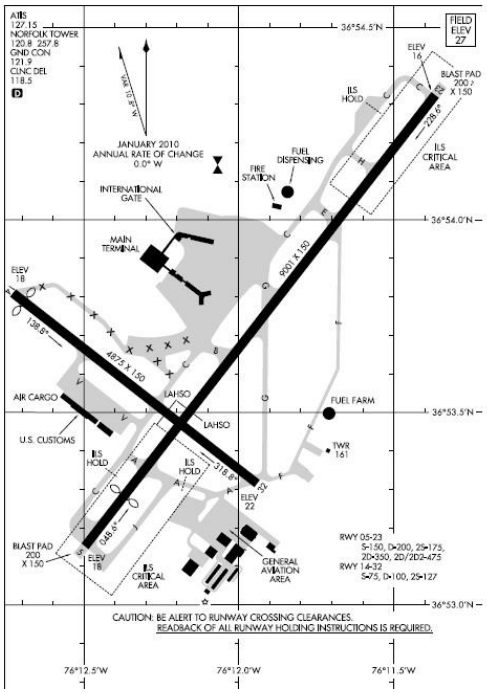


Figure 4.4: ORF Gates, Runway and Taxiway Configuration

LTO fuel consumption in 2010 for the Norfolk International Airport was determined to be 4,563,729 gallons. Therefore Cruise fuel consumption is calculated as:

27,941,000 gal -4,563,729 gal = 23,377,271 gal

Emissions attributed to the LTO cycle were calculated in the EDMS model to be 44,670 metric tons CO_2e. Emissions attributed to Cruise were determined to be 223,394 metric tons of CO_2e utilizing the emission coefficients contained in the ACRP guidebook as shown in the equation below:

$$(23{,}377{,}271 gal) \times \left(21.095 lbs \frac{CO_2}{gal fuel}\right) \times 0.0004536 metric \frac{tons}{lb} = 223{,}394\ metric\ tons\ CO_2e$$

The total emissions attributed to air travel attributed to air travel for 2010 were calculated to be 268,064 metric tons of CO_2e.

4.3.5 Waste

Solid waste generated by the Norfolk community is disposed of either by controlled incineration or by placement in a managed landfill. The CACP software was used to estimate emissions from both disposal methods. Data provided by SPSA indicated that in 2010 approximately 160,621 tons of waste was processed by the Refuse Derived Fuel (RDF) facility and an additional 38,846 tons of waste were placed in the SPSA Regional landfill.

Landfills are a significant source of GHG emissions. In 2010, fugitive emissions from landfills accounted for 16.2 percent of total anthropogenic CH_4 emissions in the United States (EPA 2012). Landfill gas is approximately half CO_2 and half CH_4 by volume and is created by the decomposition of organic material (EPA 2012).

There are many sources of GHG emissions related to solid waste handling and disposal. This section of the CACP software encompasses only GHG emissions associated with solid waste disposal facilities. Specifically this section focuses on estimating fugitive methane (CH_4) emissions from landfills and GHG emissions from controlled incineration of waste. Other sources of GHG emissions associated with solid waste handling and disposal include; CO_2, CH_4 and N_2O generated by fuel combusting equipment, waste-hauling fleet vehicles, power generated and consumed at the solid waste facility and purchased electricity. These emission sources are captured in other sectors of the Community Analysis.

4.3.5.1 Emissions Calculation Methodology

It is important to note that at the time of writing this inventory report there is no widely accepted methodology for directly measuring landfill GHG emissions. The guidance provided in the LGOP is for a conservative estimation approach that is expected to change as more research is conducted.

The quantity of fugitive CH_4 emissions from the Regional Landfill was calculated by utilizing the CACP software. The required data inputs are the waste characterization and tons of waste disposed of in the inventory year. The SPSA Regional Landfill accepts municipal solid waste from the entire Southern Hampton Roads region, which includes a number of local governments. For the purposes of this inventory the solid waste tonnage entered into the CACP software was obtained from the Norfolk tipping station for the baseline year of 2010 (38,846 tons). The waste characterization as shown in **Figure 4.5** was obtained from the annual municipal solid waste characterization fact sheet provided by the U.S. Environmental Protection Agency (EPA 2010).

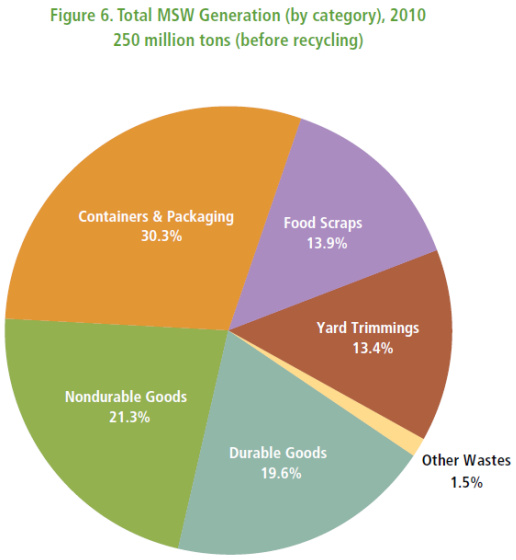


Figure 4.5: EPA 2010 MSW Waste Characterization
http://www.epa.gov/osw/nonhaz/municipal/pubs/msw_2010_rev_factsheet.pdf

The landfilled waste will be degraded over time by anaerobic bacteria. As a result, waste deposited in 2010 will produce of landfill gas (LFG) for many years. The CACP software calculated the expected total LFG generation based on a First Order Decay model. For the purposes of GHG emissions inventories it makes sense to simplify the reporting of these emissions by attributing them to the year in which the waste was created. This facilitates comparison of the baseline year with future inventories and simplifies the reporting process. The methane content of the LFG produced is assumed to be 50%. The SPSA regional landfill is required to have a LFG collection system under the US EPA's New Source Performance Standards (NSPS). The CACP software assumes that any managed landfill has a LFG collection system that successfully collects 75% of all LFG emissions. The total projected CO_2e emissions of the City of Norfolk's MSW landfilled in 2010 was calculated to be 8,450 metric tons.

The emissions due to controlled incineration at the RDF plant were also calculated with the CACP software. In 2010 the RDF plant processed 160,621 tons of MSW from the Norfolk tipping station. The waste characterization utilized was as described above. The total CO_2e emissions of the City of Norfolk's MSW incinerated at the RDF facility in 2010 was calculated to be 29,041 metric tons.

Total emissions from MSW generated in the Norfolk community in 2010 were calculated to be 37,491 metric tons CO_2e.

Conclusions

This inventory was conducted in a manner emphasizing transparency, accuracy, consistency, completeness and relevance. These five reporting principles are essential to producing an inventory that is useful for projecting future emissions and setting reduction targets.

Figure 5: ICLEI Five Milestones

The ICLEI-Local Governments for Sustainability has a five milestone process that provides a road map for local governments to achieve reductions in emissions. As shown in Figure 5.0 the first step in the process is to assemble an inventory of emissions. Once all emission sources are accounted for the next step is to establish emission reduction targets. The third milestone involves the development of a Climate Action Plan that specifies the strategies for meeting emission reduction targets. The fourth step is the implementation of the emission reduction elements developed in the Climate Action Pan. The fifth and final milestone is monitoring of progress toward emission reduction targets.

Appendix A: References

EPA, 2010. *Municipal Solid Waste Generation, and Disposal in the United States Tables and Figures for 2010.* U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. December 2011. http://www.epa.gov/osw/nonhaz/municipal/msw99.htm

EPA. 2012, *US Environmental Protection Agency Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

ICLEI, 2010. *Local Government Operations Protocol for the quantification and reporting of greenhouse gas emissions inventories.* Version 1.1, May 2010

ICLEI, 2012. *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*. Version 1.0, October 2012

Kim, B. Y., National Research Council (U.S.)., Airport Cooperative Research Program., & United States. (2009). *Guidebook on preparing airport greenhouse gas emissions inventories*. Washington, D.C: Transportation Research Board.

Appendix B: eGrid Electricity Emission Factors

Below is the table of eGRID Electricity Emission Factors by eGRID Subregion for Inventory Years 2007-Present. The City of Norfolk is located in eGRID Sub-region SRVC, which is highlighted in yellow in the table. As is common in for most regions of the country, information was not available for utility specific coefficients.

Inventory Year		2007		
eGrid Subregion	eGrid Subregion Name	CO_2 (lb/MWh)	N_2O (lb/MWh)	CH_4 (lb/MWh)
FRCC	FRCC All	1220.11	0.01525	0.04119
HIMS	HICC Miscellaneous	1343.82	0.02171	0.13515
HIOA	HICC Oahu	1620.76	0.02089	0.09105
MORE	MRO East	1692.32	0.02905	0.02879
MROW	MRO West	1722.67	0.02919	0.02897
NEWE	NPCC New England	827.95	0.01520	0.07698
NWPP	WECC Northwest	858.79	0.01364	0.01634
NYCW	NPCC NYC/Westchester	704.80	0.00335	0.02622
NYLI	NPCC Long Island	1418.74	0.01310	0.09050
NYUP	NPCC Upstate NY	683.27	0.00990	0.01741
RFCE	RFC East	1059.32	0.01703	0.02740
RFCM	RFC Michigan	1651.11	0.02779	0.03255
RFCW	RFC West	1551.52	0.02593	0.01837
RMPA	WECC Rockies	1906.06	0.02889	0.02363
SPNO	SPP North	1798.71	0.02920	0.02122
SPSO	SPP South	1624.03	0.02242	0.02452
SRMV	SERC Mississippi Valley	1004.10	0.01115	0.02180
SRMW	SERC Midwest	1779.27	0.02960	0.02057
SRSO	SERC South	1495.47	0.02457	0.02364
SRTV	SERC Tennessee Valley	1540.85	0.02548	0.01987
SRVC	SERC Virginia/Carolina	1118.41	0.01908	0.02226
Source		eGRID2010 Version 1.1 (Year 2007)		

Appendix C: Example CO_2e Calculation

The following is an example of the calculations performed by the CACP software. The CACP calculates emissions of CO_2, N_2O and CH_4 due to electricity consumption based on the coefficients listed for the selected eGRID Subregion. The City of Norfolk is located in the SRVC eGrid Subregion. The default CACP coefficients were used for natural gas calculations. The GWP of each gas is used to convert emissions to CO_2e.

Chrysler Museum

2010 Electricity Consumption = 5,211,232 kWh
5211.232 MWh

	CO_2	N_2O	CH_4
SRVC Subregion eGRID coefficients (lbs/MWh)	1,118.40	0.02	0.02
Global Warming Potential Factor	1	310	21
2010 lbs	5,828,241.87	99.01	114.65
Metric Tons	2,643.63	0.04	0.05
Metric Tons CO_2e	2,643.63	13.92	1.09

Total Metric Tons of CO_2e Produced = 2,659

1 kWh = 0.001 MWh
1 lbs = 0.00045359 metric tons

Residential Sector

2010 Natural Gas Consumption = 2,746,700 MMBtu

	CO_2	N_2O	CH_4
CACP Coefficient (kg/MMBtu)	53.02	0.0001	0.005
Global Warming Potential Factor	1	310	21
2010 kg	145,630,034.00	274.67	13,733.50
Metric Tons	145,630.03	0.27	13.73
Metric Tons CO_2e	145,630.03	85.15	288.40

Total Metric Tons of CO_2e Produced = 146,004