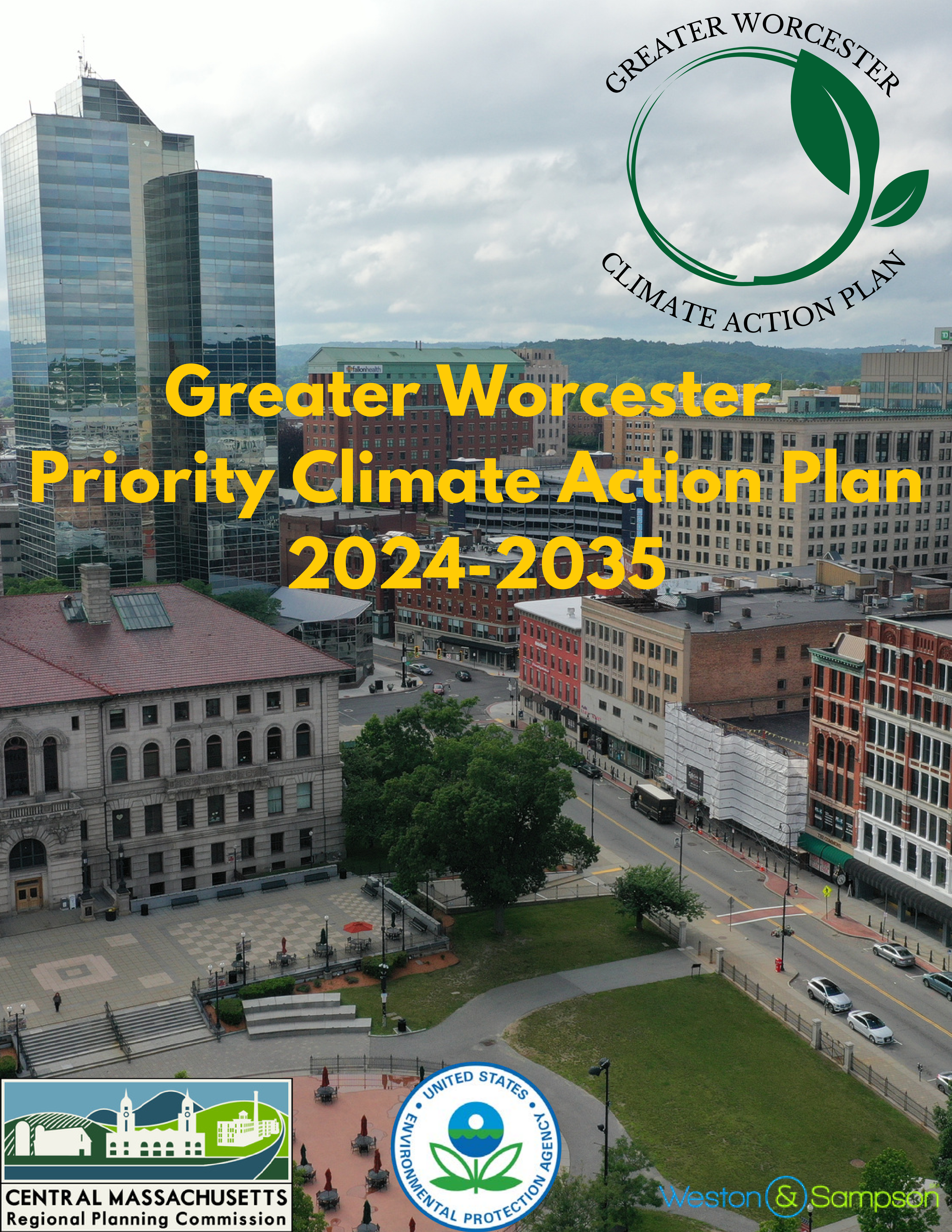

GREATER WORCESTER CLIMATE ACTION PLAN

Greater Worcester Priority Climate Action Plan 2024-2035

CENTRAL MASSACHUSETTS Regional Planning Commission

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Weston & Sampson

Dear Reader,

It is with my greatest sincerity that I thank you for taking the time to read the Greater Worcester Priority Climate Action Plan. This plan is a labor of love for the many staff members and stakeholders that gave their time for the development of this important document. It is our intent that this plan will begin a long-lasting and fruitful conversation in Central Massachusetts and Northeast Connecticut about the impact and benefits of air pollution reduction efforts and how it can transform the region for the better.

The Greater Worcester Priority Climate Action Plan is one part of a larger planning effort known as the Climate Pollution Reduction Grant; a federal Environmental Protection Agency program funded through the Inflation Reduction Act signed into law by President Biden in 2022. This is a four-year grant process where Central Massachusetts Regional Planning Commission will lead the planning process for the Greater Worcester Region, which consists of Worcester County Massachusetts, Windham County Connecticut, and several surrounding communities.

The Greater Worcester Priority Climate Action Plan highlights six key emissions sectors and their impact on the overall air quality and pollution for the region: transportation, electricity, waste management, residential & commercial buildings, industry, and agricultural & natural lands. The plan then sets out twenty priority strategies that can be implemented locally and regionally to reduce greenhouse gas emissions and air pollution. Staff, along with our partner agencies Montachusett Regional Planning Commission and Northeast Connecticut Council of Government, met with stakeholders, the public, and town officials to discuss the needs, concerns, and ideas for the region and how we can improve the air quality for everyone who lives and works here. This is as much their plan as it is ours.

We hope this plan can be used as a vital resource for municipalities looking to reduce their greenhouse gas emissions and improve the quality of life for their residents. As we continue to move through the Climate Pollution Reduction Grant process, we will continue to work closely with regional stakeholders and the States of Massachusetts and Connecticut to bring this plan to life in innovative and effective ways. CMRPC looks forward to the opportunity to create a lasting, positive impact on the Greater Worcester region. Thank you again for taking the time to read through this plan and thank you to everyone who had a hand in bringing it to fruition.

Sincerely,

Janet Pierce
Executive Director
Central Massachusetts Regional Planning Commission

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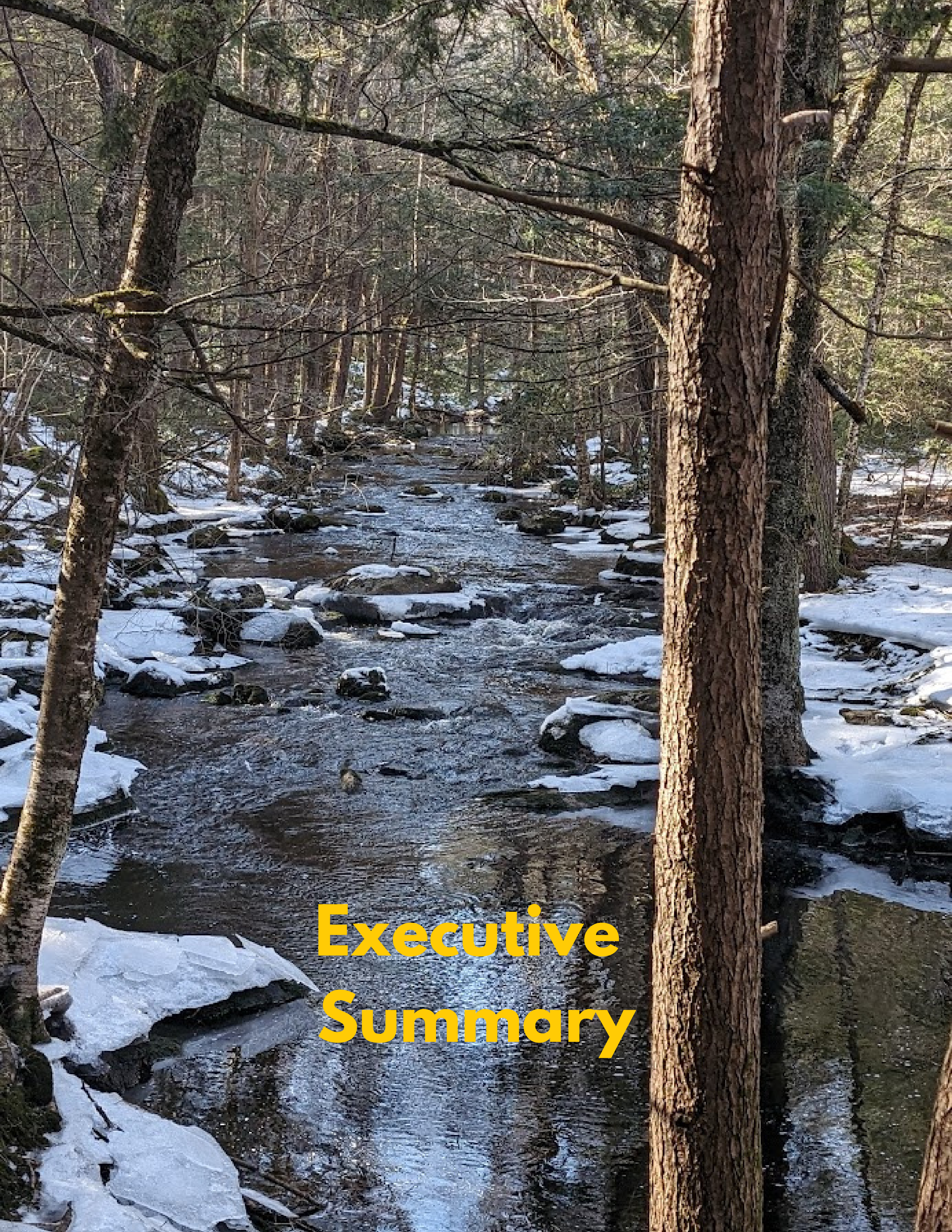

Executive Summary

Executive Summary

Introduction

The Greater Worcester GWPCAP (GWPCAP) has been developed as part of a U.S. Environmental Protection Agency (EPA) Climate Pollution Reduction Grant (CPRG) Phase 1 Planning Grant. To reduce greenhouse gas emissions throughout Central Massachusetts and Northeast Connecticut, the Central Massachusetts Regional Planning Commission (CMRPC) partnered with the Montachusett Regional Planning Commission (MRPC) and the Northeast Connecticut Council of Governments (NECCOG) to determine twenty priority measures for reducing emissions that aligned with the public's needs and concerns for the region. For the region to achieve the climate goals of both Massachusetts and Connecticut, these measures are meant to be implemented in the short-term (up to 2035) and monitored for emissions reductions. CMRPC worked with Weston & Sampson, Inc to develop an emissions baseline for 2017 and to quantify the emissions reductions for each measure. This plan represents the feedback of ten community outreach events, two public surveys, and countless hours of one-on-one conversations with stakeholders. CMRPC and partner organizations intend to use this plan to seek out funds to implement the many incredible and important projects described below. Six key emissions sectors were examined as part of the plan: Transportation, Electricity, Residential & Commercial Buildings, Industry, Waste Management, and Agricultural, Natural & Working Lands. Throughout the planning process, CMRPC found that the highest priorities for the region includes waste reduction through composting, weatherization of old housing stock, expanding fare-free public transit services, and expanding solar coverage in appropriate areas such as brownfields and rooftops.

CMRPC would like to thank everyone who attended and contributed to the community workshops, responded to the surveys, and answered calls for input and advice when creating this plan; it is as much theirs as it is ours. CMRPC would like to give particular thanks to our partner organizations, MRPC and NECCOG, for their help in shaping the plan, the States of Massachusetts and Connecticut for their support throughout the process, the EPA for providing us with this opportunity, and the team at Weston & Sampson for all the data analytics and calculations.

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Glossary of Terms & Acronyms

Adaptation: a change or the process of change by which an organism or species becomes better suited to its environment

Anaerobic digester: a sealed, oxygen-free tank designed for the anaerobic digestion of sewage or other organic waste by microorganisms, typically used as a means of waste disposal or energy production [i]

Biogas: renewable fuel produced by the bacterial decomposition of organic wastes without oxygen, mainly consisting of methane and carbon dioxide with trace amounts of other gases.

Biological Carbon Sequestration: A natural or artificial process that removes carbon dioxide from the atmosphere and holds it in solid or liquid form; there are two main types of carbon sequestration, including geologic and biologic carbon sequestration[ii]

Central Massachusetts Regional Planning Commission (CMRPC): One of 13 Regional Planning Agencies in Massachusetts, CMRPC serves the City of Worcester and 39 surrounding communities in the southern two-thirds of Worcester County.

Circular Economy: an economy that keeps materials and products in circulation for as long as possible; reduces material use, redesigns materials and products to be less resource intensive, and recaptures "waste" as a resource to manufacture new materials and products [iii]

Connecticut-designated Environmental Justice Areas: An environmental justice community is defined by the Connecticut General Statues as: defined census blocks where 30% of the population is living below 200% of the federal poverty level[iv]

Electricity Transmission and Distribution (T&D): Electricity generated at power plants is delivered to customers through transmission and distribution power lines. Transmission is over long distances through high voltage power lines, such as tall metal towers covering large areas. Distribution is through low voltage power lines in much shorter distances, this is much safer for use in homes and businesses.[v]

Environmental Justice (EJ): the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other activities that effect human health and the environment [vi]

Greater Worcester Priority Climate Action Plan (GWPCAP): outlines near-term carbon reduction measures ready for implementation in 2025-2030. PCAP measures must lessen GHG emissions and air pollution and benefit low-income and disadvantaged communities (LIDACs).[vii]

Greenhouse Gases (GHGs): any gas that has the property of absorbing infrared radiation emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect.

Justice40: Federal government initiative stating that of certain federal investments, 40% of the funding should benefit certain low-income disadvantaged communities[viii]

Low-Income Disadvantaged Community (LIDAC): Any community that meets at least one of the following characteristics: Identified as disadvantaged by the Climate and Economic Justice Screening Tool (CEJST); Any census block group that is at or above the 90th percentile for any of EJScreen's Supplemental Indexes when compared to the nation or state, and/or Any geographic area within Tribal lands as included in EJScreen. [ix]

Low-Impact Development (LID): systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater to protect water quality and associated aquatic habitat[x]

Manure Shed: A manure shed encompasses the lands surrounding animal feeding operations onto which manure nutrients can be redistributed to meet environmental, production, and economic goals[xi]

Massachusetts-Designated Environmental Justice Areas: a neighborhood where one or more of the following criteria are true: the annual median household income is 65 percent or less of the statewide annual median household income, minorities make up 40% or more of the population, 25% or more of households identify as speaking English less than "very well", minorities make up 25% or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150% of the statewide annual median household income.[xii]

Metropolitan Statistical Area (MSA): a region that consists of a city and surrounding communities that are linked by social and economic factors, as established by the U.S. Office of Management and Budget.

Mitigation: making something less severe, dangerous, painful, harsh, or damaging

Montachusett Regional Planning Commission (MRPC): The MRPC is the Regional Planning Agency for the towns in greater north central Massachusetts. MRPC carries out a variety of projects for the municipalities in their region, from transportation planning to comprehensive planning. [xiii]

MT CO2: Metric tons of carbon dioxide

MT CO2e: Metric tons of carbon dioxide equivalent

MT CH4: Metric tons of methane

MT N2O: Metric tons of nitrous oxide

Northeastern Connecticut Council of Governments (NECCOG): a state leader in the innovation, development, advocation and application of regionalism, is a 16-town regional council of governments founded in 1987. NECCOG is a chief-elected official driven — organized forum for the member towns to discuss, facilitate and develop responses to issues of mutual concern. NECCOG's member towns are Ashford, Brooklyn, Canterbury, Chaplin, Eastford, Hampton, Killingly, Plainfield, Pomfret, Putnam, Scotland, Sterling, Thompson, Union, Voluntown and Woodstock. Each municipality is represented by their respective chief-elected official. NECCOG is statutorily authorized but has no regulatory power.[xiv]

Pay-As-You-Throw/Unit-Based Pricing: a materials management model where entities are charged for trash they throw away. In communities with pay-as-you-throw programs, residents are charged for the collection of municipal solid waste based on the amount they throw away, creating a direct economic incentive to recycle more and to generate less waste.[xv]

Per-and Polyfluoroalkyl Substances (PFAS): a group of chemicals used to make fluoropolymer coatings and products that resist heat, oil, stains, grease, and water.[xvi]

PM2.5: Particulate matter, also known as particulate pollution, with diameters that are generally 2.5 micrometers and smaller.[xvii]

Protected Bike Lane: a bike lane that is physically separated from sidewalks and motor vehicle traffic. Separation can be provided by various physical features, such as raised curbs, bollards, vehicle parking, or planter strips.[xviii]

Regional Planning Agency (RPA): government body that guides the development of public and private resources to ensure public safety, well-being, and livability. Addresses planning issues that cross local jurisdictional boundaries such as transportation or watershed protection. [xix]

Regional Transit Authority (RTA): Regional Transit Authorities are established by the state to provide a public transportation system under the control of municipalities. Each RTA supports several communities and is governed by an advisory board composed of the chief elected officials from those communities. [xx]

Shared Use Path: facilities on exclusive right-of-way and with minimal flow by motor vehicles. Intended for use by pedestrians and must meet accessibility guidelines for walkways and curb transitions.[xxi]

Waste-To-Energy (WTE) Facility: waste management facility that combusts waste to produce electricity. These plants burn municipal solid waste such as paper, plastics, yard waste, and products made from wood, to produce steam in a boiler.[xxii]

2008 Global Warming Solutions (GWS) Act: set economy-wide greenhouse gas (GHG) emission reduction goals for Massachusetts that will achieve reductions of: Between 10 percent and 25 percent below statewide 1990 GHG emission levels by 2020 and at least 80 percent below statewide 1990 GHG emission levels by 2050. Established two advisory committees to provide input on the implementation of the GWSA: The Climate Protection and Green Economy Advisory Committee and The Climate Change Adaptation Advisory Committee. [xxiii]

2021 MA Climate Law: Created a Next-Generation Roadmap for MA Climate Policy, which requires the EEA to set interim emissions limit and sector-specific sub-limits every 5 years. Sets emissions limits of 50% below 1990 levels by 2030 and 75% cuts by 2040 with interim limits every five years. Establishes new goals for emission reductions and significantly increases protections for Environmental Justice communities.[xxiv]

Background

Background

EPA Climate Pollution Reduction Grant Program

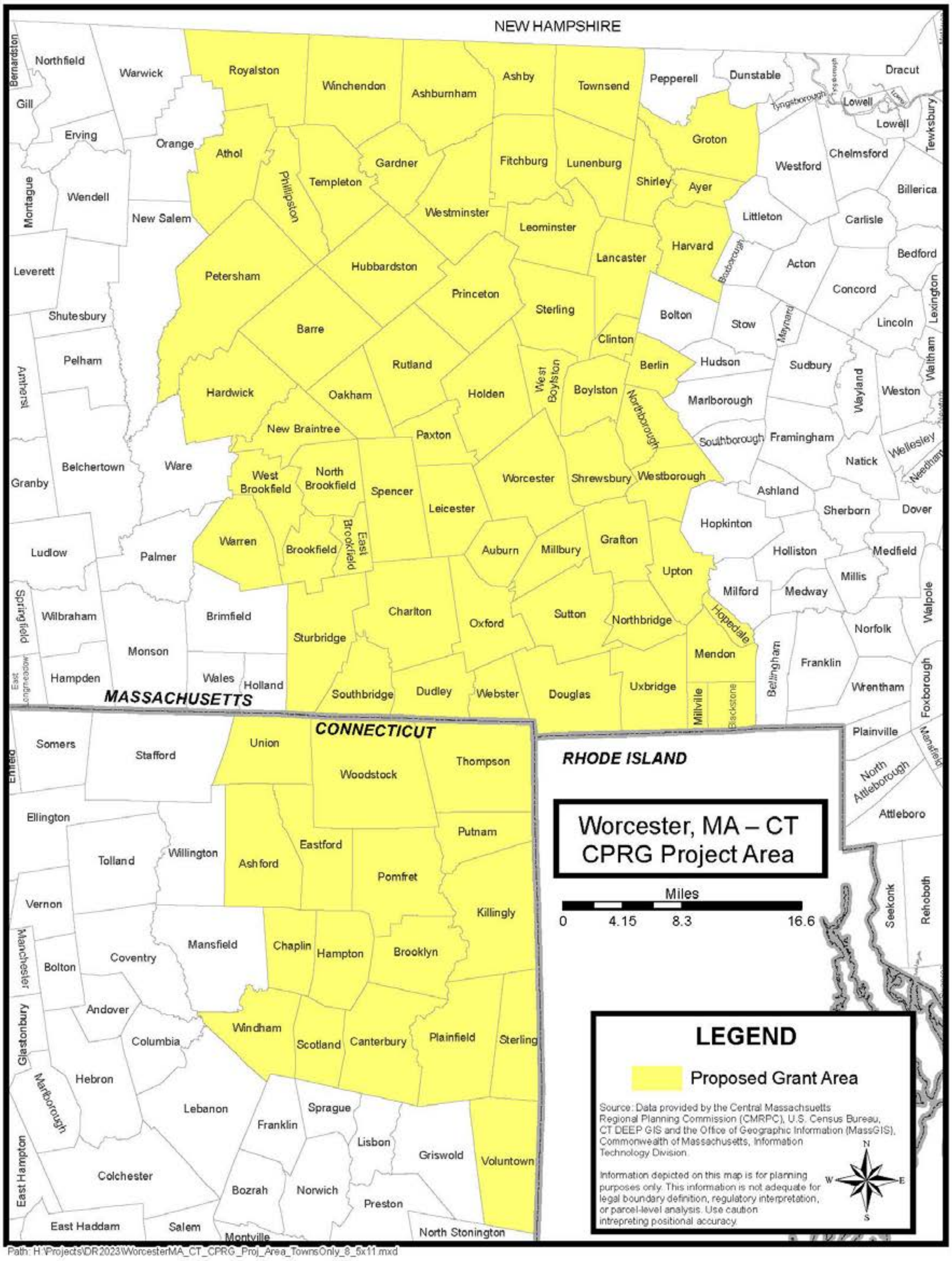
When President Biden signed the Inflation Reduction Act in August 2022, $5 billion of that act was set aside for the EPA to create the Climate Pollution Reduction Grant. The Climate Pollution Reduction Grant (CPRG) provides $250 million in financial support through grants to states, local governments, tribes, and territories throughout the United States to develop priority and comprehensive plans to reduce greenhouse gas emissions and other harmful air pollution. $4.6 billion is also allocated for competitive implementation grants to bring projects identified through the planning process to life. In March 2023, the CPRG program was announced, and in May 2023, CMRPC applied to the EPA to be the lead entity for the Worcester MA-CT Metro area, referred to throughout this plan as the Greater Worcester Region. In August 2023, CMRPC was awarded $1 million for a planning grant and began work on the GWPCAP. The CPRG planning process will take four years to complete and is comprised of various milestones:

1. Priority Climate Action Plan – Due March 1, 2024
2. Comprehensive Climate Action Plan – Due Mid-2025
3. Status Report – Due Mid-2027

While the GWPCAP is focusing on short-term, implementable projects and looks out to 2035, the Comprehensive Climate Action Plan will focus on long-term projects, strategies, policies, and procedures to bring greenhouse gas emissions in the region to zero or even net-negative by 2050. The status report will be submitted at the end of the four-year grant and will reflect on the completed work and what is needed for the region to stay on pace for the 2050 benchmark. The planning area for the Greater Worcester Region includes eighty communities in Massachusetts and Connecticut. This includes all of Worcester County Massachusetts, all of Windham County Connecticut, one town in Tolland County Connecticut, one town in New London County Connecticut, and five towns in Middlesex County Massachusetts. There is also Fort Devens, a regional enterprise zone and a census designated place.

Ashburnham, MA	Ashby, MA	Ashford, CT
Athol, MA	Auburn, MA	Ayer, MA
Barre, MA	Berlin, MA	Blackstone, MA
Bolton, MA	Boylston, MA	Brookfield, MA
Brooklyn, CT	Canterbury, CT	Chaplin, CT
Charlton, MA	Clinton, MA	Douglas, MA
Dudley, MA	East Brookfield, MA	Eastford, CT

Fitchburg, MA
Gardner, MA
Grafton, MA
Groton, MA
Hampton, CT
Hardwick, MA
Harvard, MA
Holden, MA
Hopedale, MA
Hubbardston, MA
Killingly, CT
Lancaster, MA
Leicester, MA
Leominster, MA
Lunenburg, MA
Mendon, MA
Millbury, MA
Millville, MA
New Braintree, MA
North Brookfield, MA
Northborough, MA
Northbridge, MA
Oakham, MA
Oxford, MA
Paxton, MA
Petersham, MA
Phillipston, MA
Plainfield, CT
Pomfret, CT
Princeton, MA
Putnam, CT
Royalston, MA
Rutland, MA
Scotland, CT
Shirley, MA
Shrewsbury, MA
Southbridge, MA
Spencer, MA
Sterling, MA
Sterling, CT
Sturbridge, MA
Sutton, MA
Templeton, MA
Thompson, CT
Townsend, MA
Union, CT
Upton, MA
Uxbridge, MA
Voluntown, CT
Warren, MA
Webster, MA
West Boylston, MA
West Brookfield, MA
Westborough, MA
Westminster, MA
Winchendon, MA
Windham, CT
Woodstock, CT
Worcester, MA

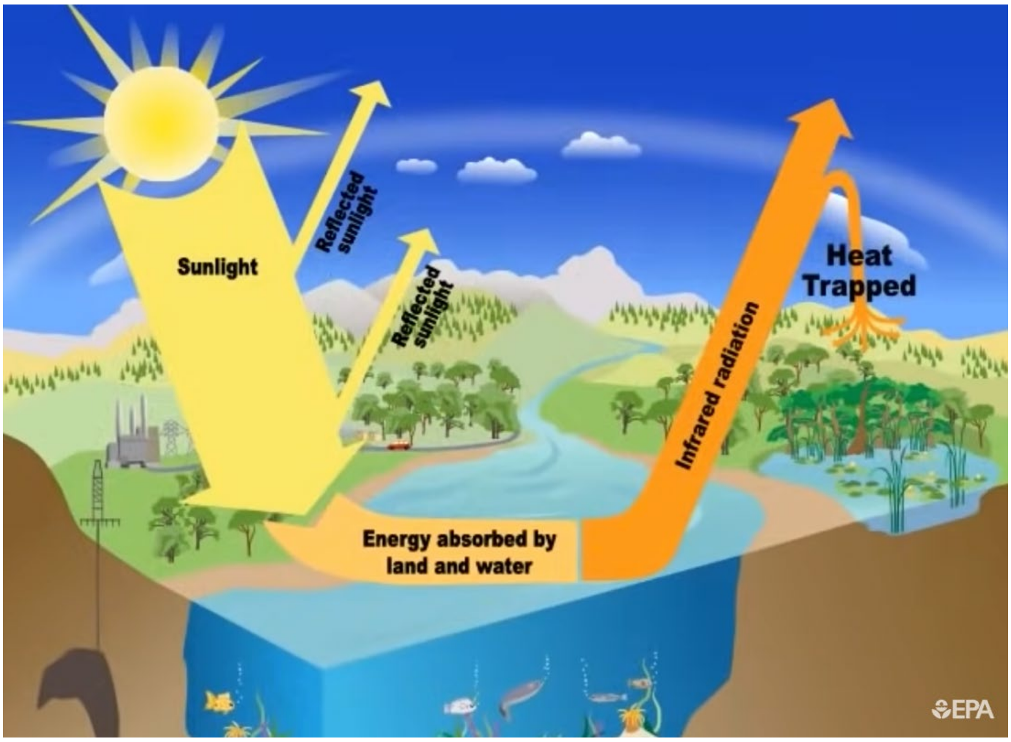


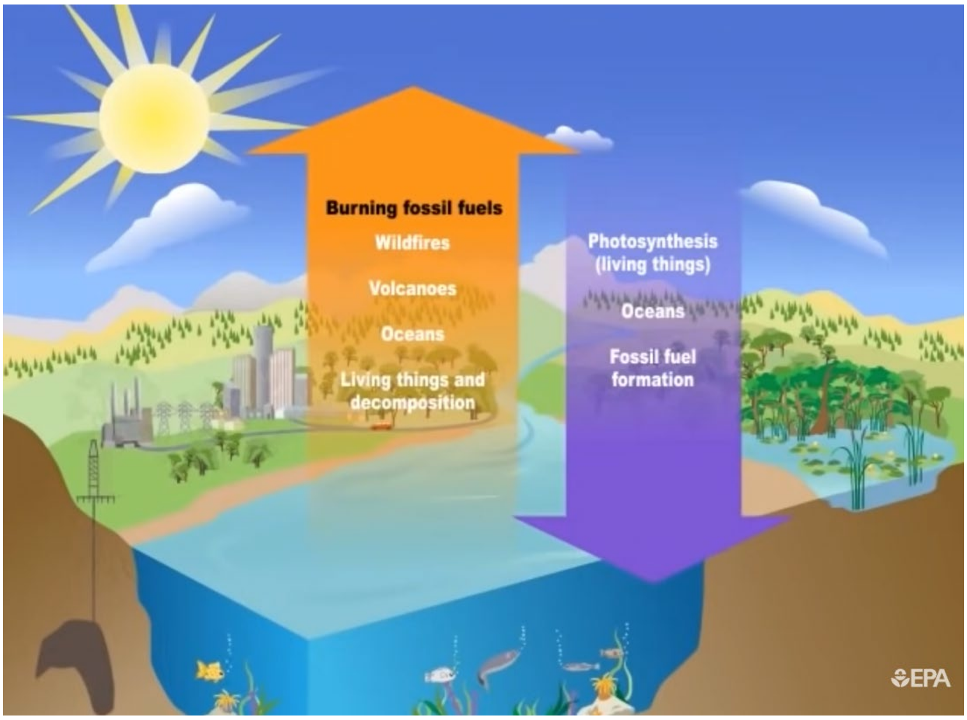
Anthropogenic Amplification of the Greenhouse Effect

The Earth's natural greenhouse effect is vital to sustain life on our planet. When the sun warms Earth, some solar radiation reflects off of the earth and back out into space. The natural Greenhouse Effect occurs when "greenhouse gases," such as carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, and water vapor, trap solar radiation in the Earth's atmosphere close to the Earth's surface. At naturally occurring levels, the heat trapping properties of atmospheric greenhouse gases are essential to trap solar radiation that has bounced off the earth and is headed back to space. This warms the planet to the perfect level to sustain terrestrial life. According to National Aeronautics and Space Administration (NASA), without the naturally occurring amount of greenhouse gases, Earth's temperature would instantly drop by over 30 degrees F, throwing off the balance of the entire earth's ecosystems.[xxv]

However, just as essential as the presence of greenhouse gases in the atmosphere is having the right amount of them. The naturally occurring greenhouse effect includes the ideal amount of heat trapping gases to keep the Earth's climate balanced - not too hot and not too cold. Just like having too few atmospheric greenhouse gases will make the earth too cold, having too many of these gases in the atmosphere will make the earth too warm. Increase in temperature will also throw all climatological processes, such as rain, storms, sea level, ice-melt, and more, out of balance.

This is where the problem of the modern-day arises. The amount of atmospheric greenhouse gases fluctuates normally over hundreds of millennia. However, since the mid-19th Century, human societies have been adding more greenhouse gases to the atmosphere every day. As a result, in the last less than two hundred years, climate scientists have observed a warming trend accelerated to a rate much faster than Earth has seen in the preceding hundreds of thousands of years before today. The start of this unprecedented, rapid warming of the earth is correlated with the start of the Industrial Revolution in the mid-1800s.[xxvi] This is when humans began mass combustion of fossil fuels to harness energy, while simultaneously removing naturally occurring carbon sinks through activities such as forest clearing.





Source: United States Environmental Protection Agency[xxvii]

The diagrams above show an illustration of how human activities emit excess greenhouse gases, such as carbon dioxide and methane (represented by the gaseous clouds) into the atmosphere as a byproduct of combustion of fossil fuels. With the addition of these excess greenhouse gases into the atmosphere, too much solar radiation is trapped close to earth, throwing off the natural greenhouse effect maintaining the Earth's temperature. The science of this issue warrants action across all human society to utilize other, non-air polluting technology to harness energy, and be innovative to develop society while preserving carbon sinks.

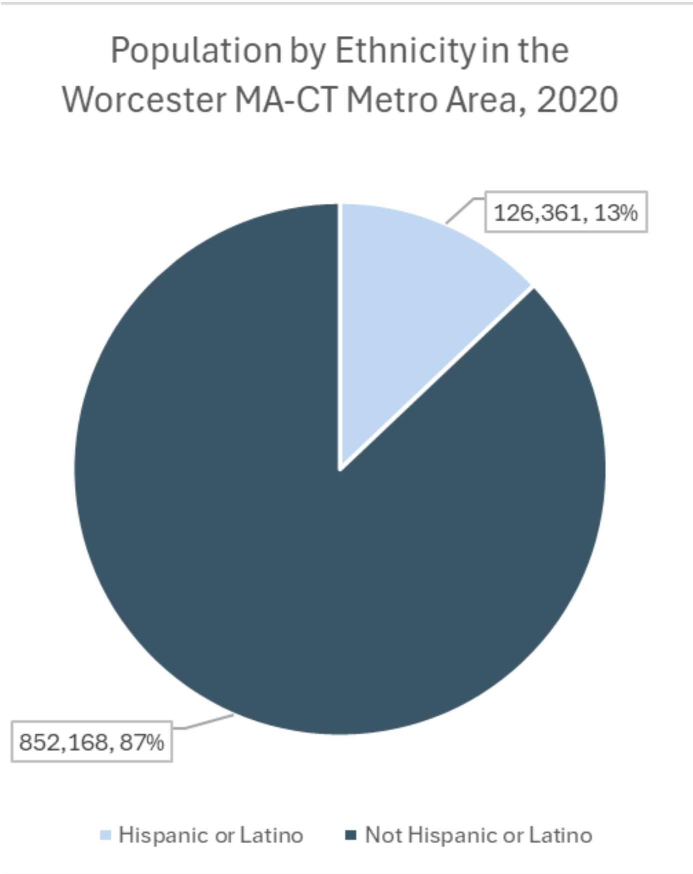
Regional Context – Worcester County & Eastern Connecticut

*The Greater Worcester MA-CT CPRG Planning Region is not completely synonymous with the Worcester MA-CT Metro Area. The municipalities of Ashby, Townsend, Shirley, Groton, and Ayer in Massachusetts as well as Union and Voluntown in Connecticut are located within the former and not the latter, while the municipalities of Southborough and Milford in Massachusetts are located within the latter and not the former. In this regional context section, the maps and tables relate to the Greater Worcester MA-CT CPRG Planning Region, while the charts relate to the Worcester MA-CT Metro Area.

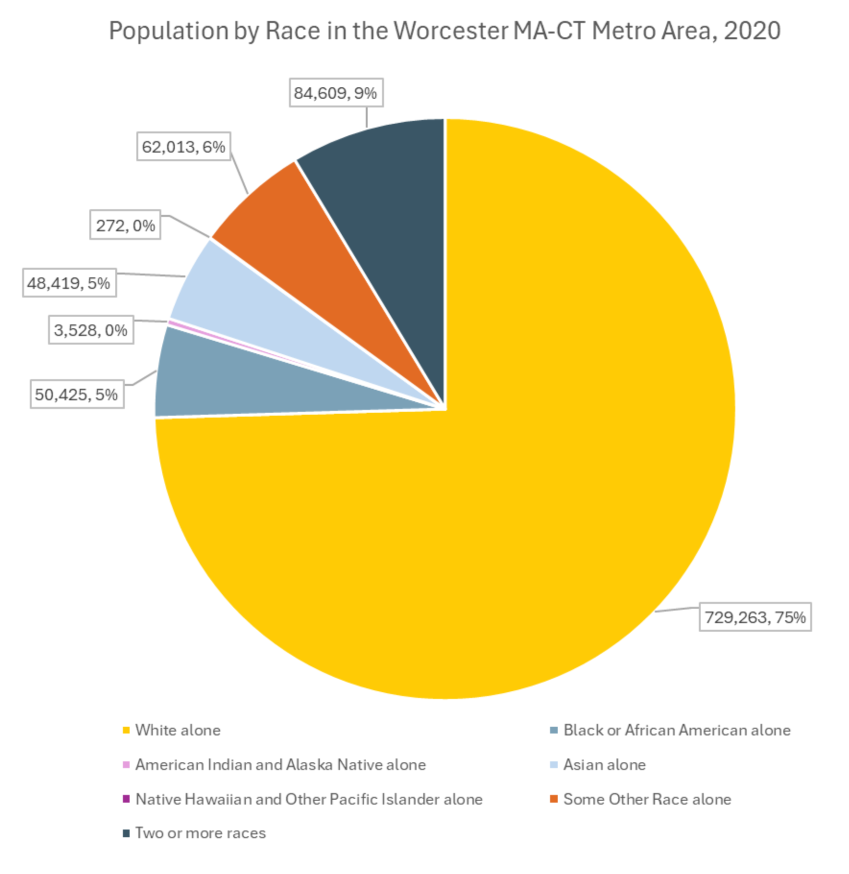
Demographics

1. Race and Ethnicity

The Greater Worcester region is home to people with a wide variety of racial, ethnic, and cultural backgrounds. According to the 2020 US Decennial Census, approximately 1/4[th] of residents identifies as a race other than white or with two or more races, while 13% of residents of any race identify as Hispanic or Latino. There are large communities of African Americans, Asian Americans, and Hispanic and Latino Americans who have lived in the region for a long time, as well as recent immigrants from Africa, Asia, Latin America, and other parts of the world who now call the region home. There are also many mixed-race families in the region. The Nipmuc and Pequot-Mohegan tribes of Native Americans who live in the region are the descendants of some of the first people who lived in the region.

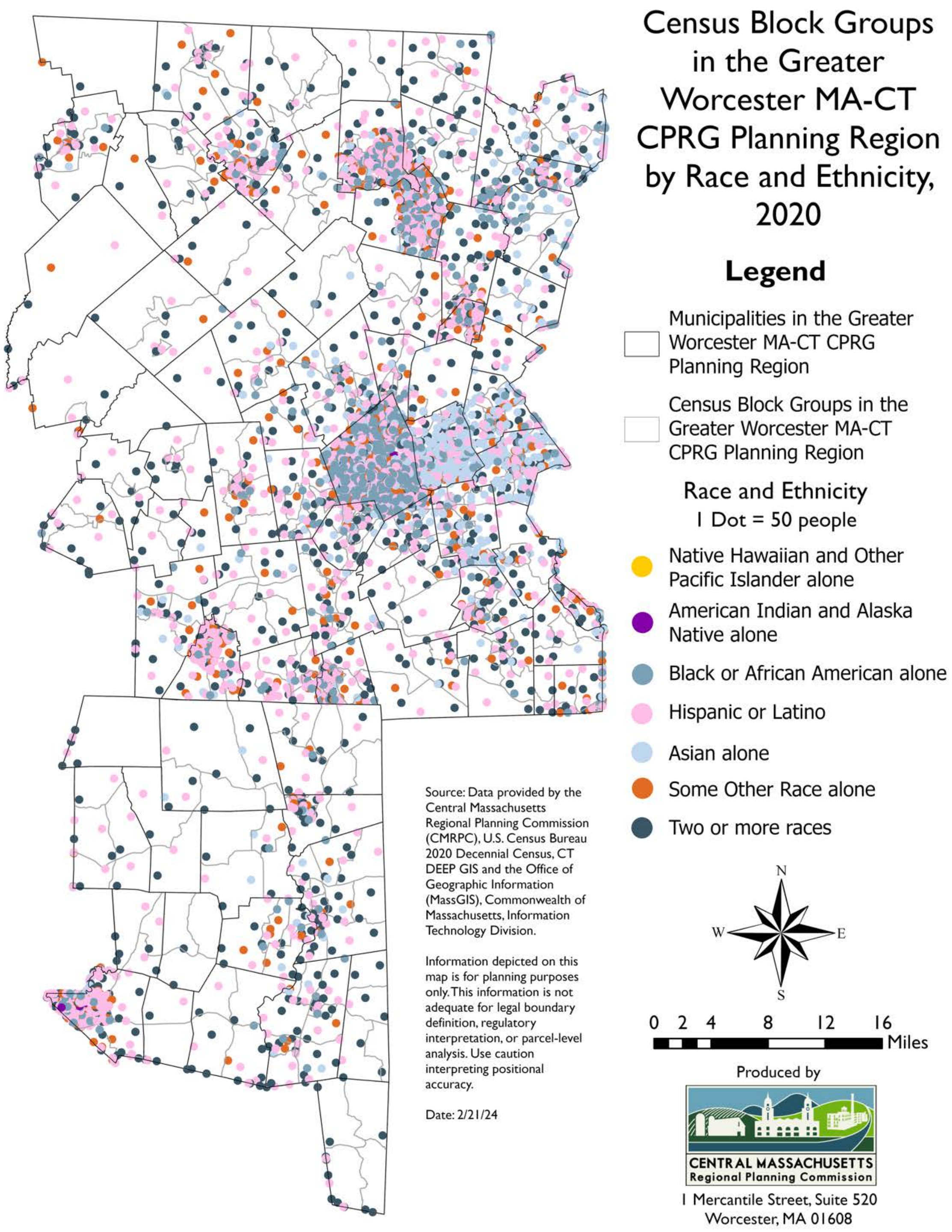


Source: 2020 US Decennial Census [xxviii]



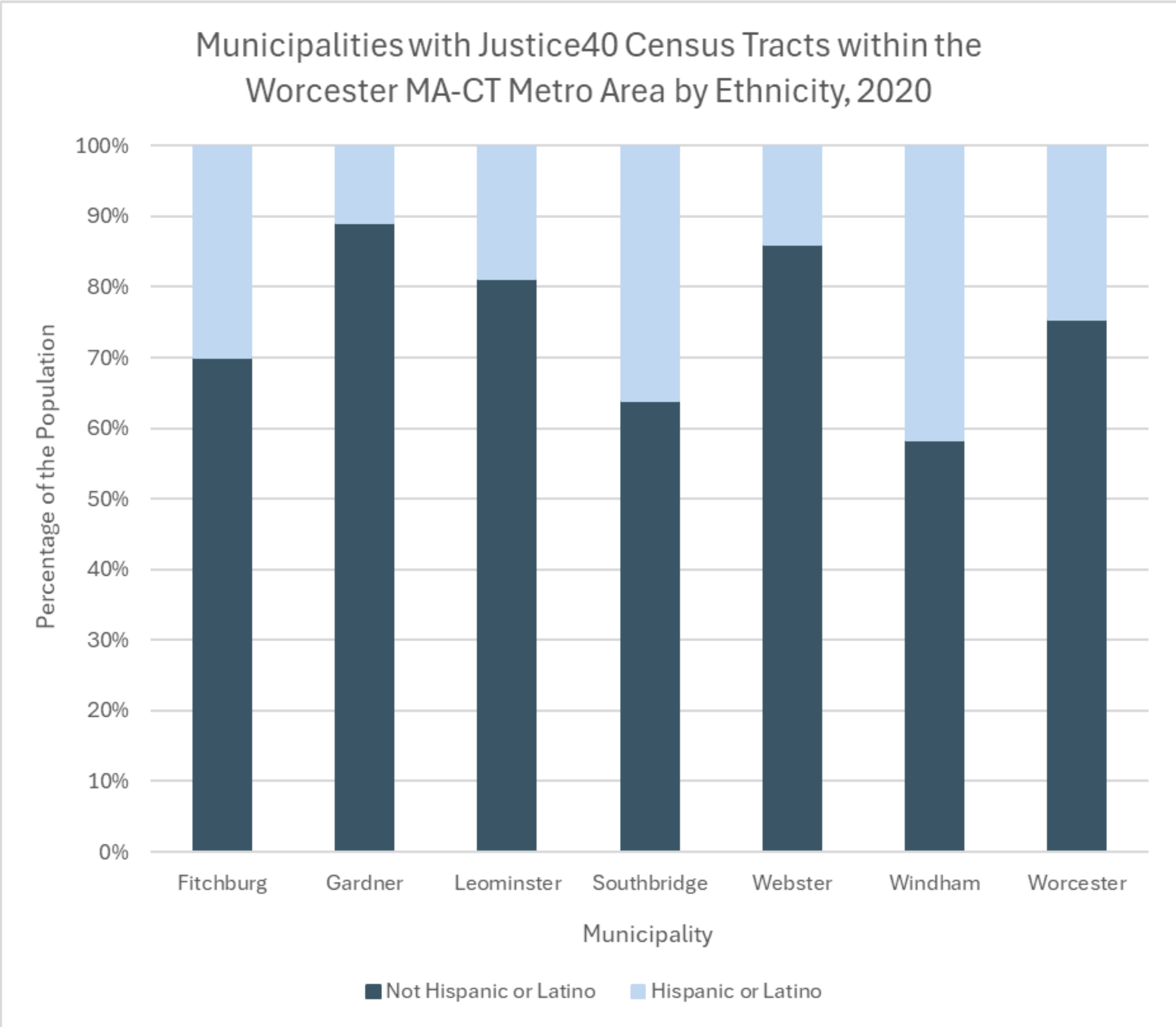
Source: 2020 US Decennial Census [xxix]

The largest communities of non-white residents in the Greater Worcester region live in urban areas, especially within the seven municipalities with federally designated Justice40 LIDAC Census Tracts within them: Fitchburg, Gardner, Leominster, Southbridge, Webster, and Worcester in Massachusetts as well as Windham in Connecticut. Other parts in the region with substantial BIPOC communities include the towns east and southeast of Worcester, towns east of Leominster and Fitchburg, towns along the Quinebaug River in Connecticut, and the towns of Athol, Clinton, and Dudley. These communities have faced environmental injustice, societal exclusion, and disinvestment and are disproportionately affected by health risks that stem from air and climate pollution. It is vital for members of these communities to be meaningfully included in the implementation of this GWPCAP.



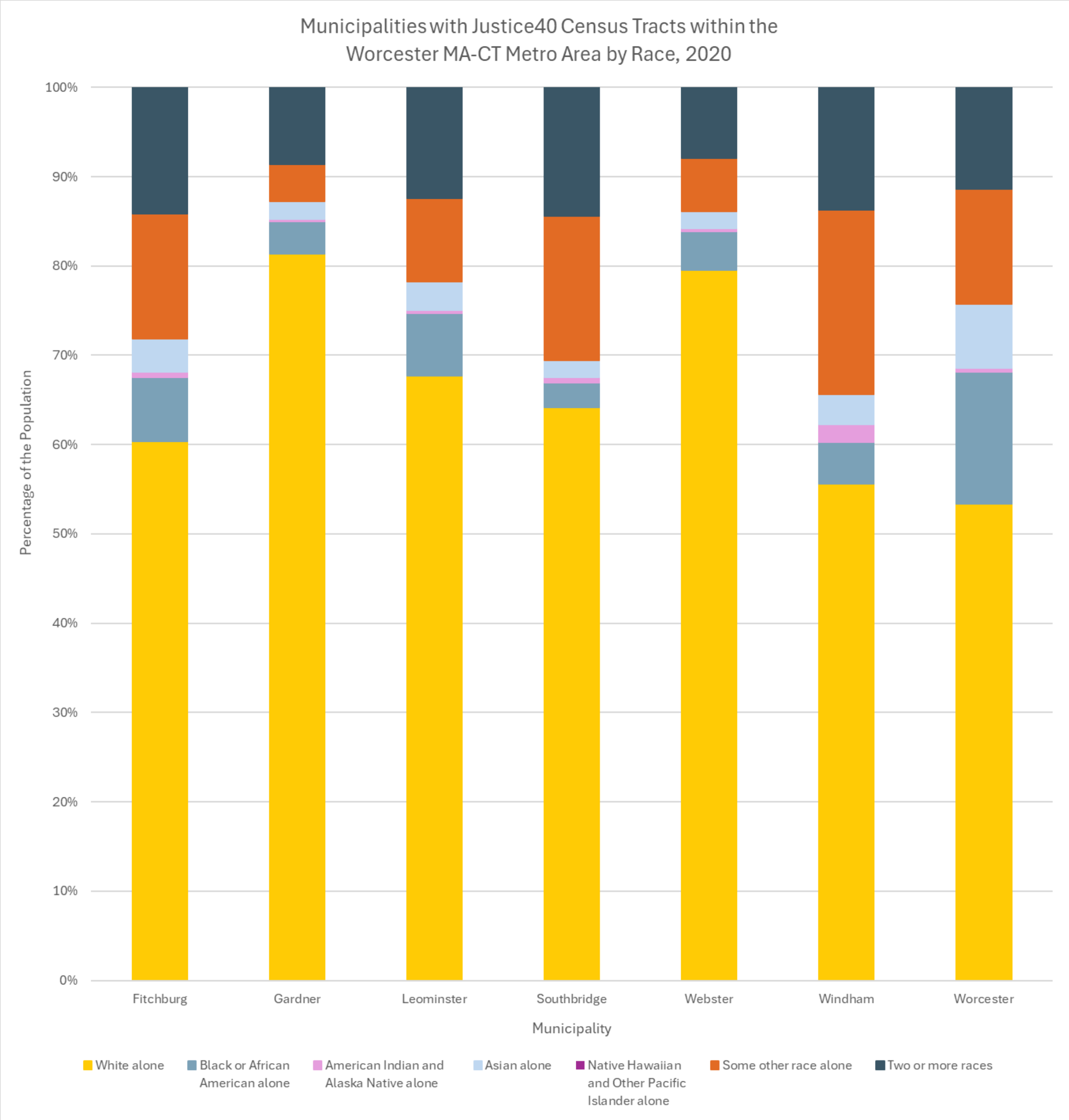
Source: 2020 US Decennial Census [xxx]

By percentage of the municipality's population, the largest Hispanic or Latino communities in municipalities with Justice40 LIDAC Census Tracts in the Greater Worcester region are in Windham, Southbridge, and Fitchburg.



Source: 2020 US Decennial Census [xxxi]

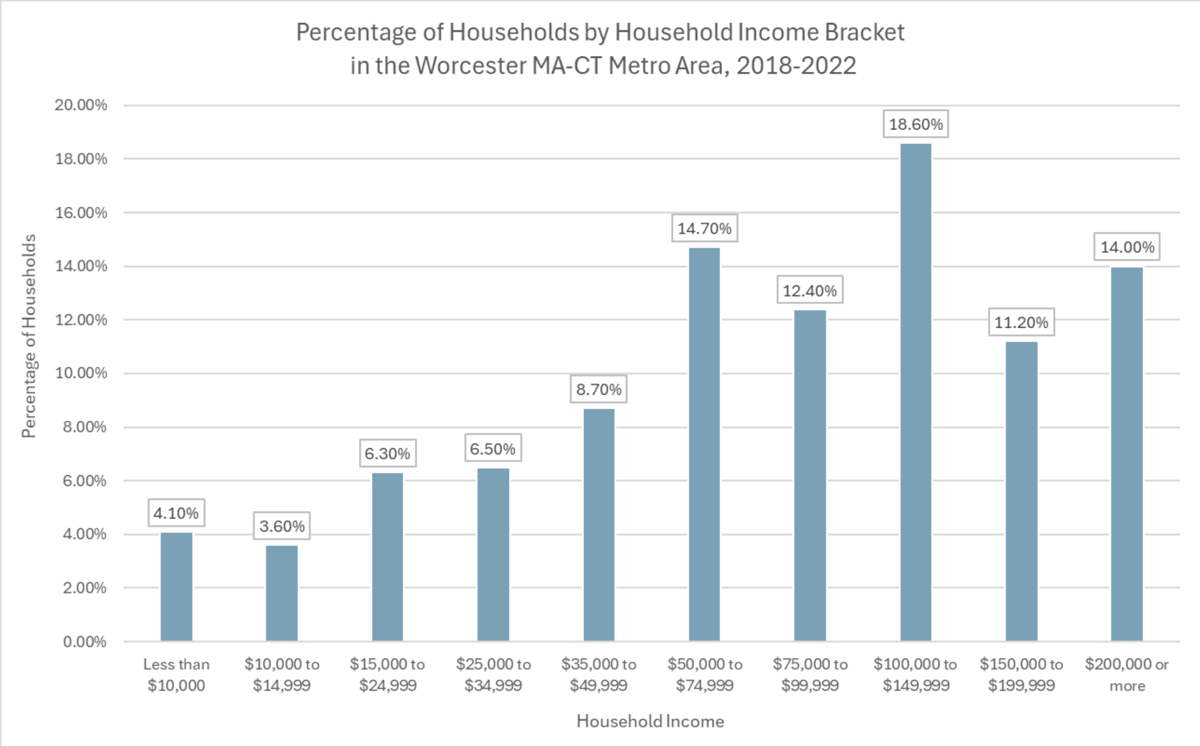
By percentage of the municipality's population, the largest Black or African American community in municipalities with Justice40 LIDAC Census Tracts in the Greater Worcester region is in Worcester; Fitchburg and Leominster also have large Black or African American communities. By percentage of the municipality's population, the largest Asian community in municipalities with Justice40 LIDAC Census Tracts in the Greater Worcester region is also in Worcester. By percentage of the municipality's population, the largest Native American community in municipalities with Justice40 Census Tracts in the Greater Worcester region is in Windham. Between 10-35% of the population in all the municipalities with Justice40 LIDAC Census Tracts in the Greater Worcester region identify as some other race or two or more races.



Source: 2020 US Decennial Census [xxxii]

2. Income

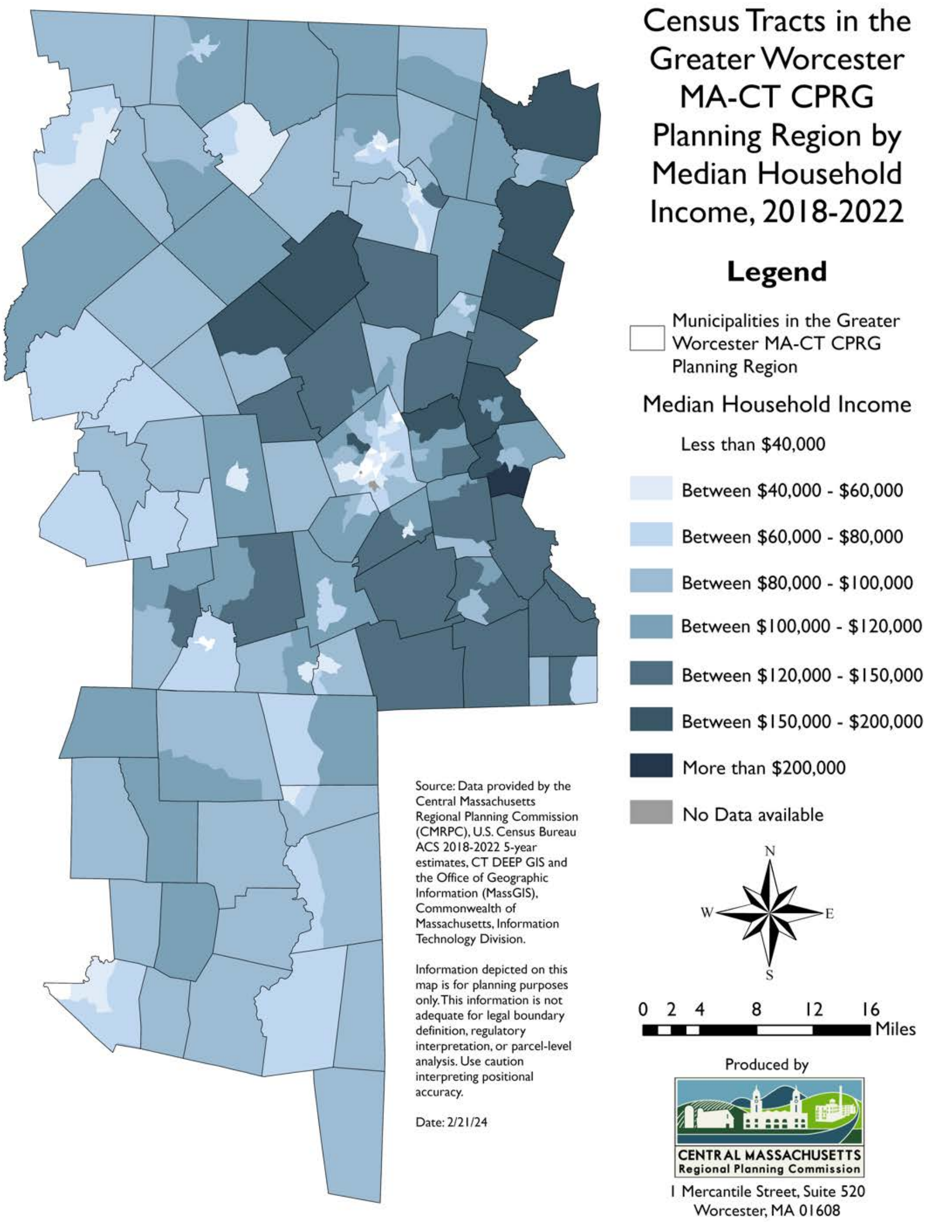
Although there are many households in the Greater Worcester region who are comfortable, a significant percentage of the region's population is struggling economically and has difficulties making ends meet. Close to 30% of households in the region have yearly incomes which are lower than $50,000, according to 2018-2022 5-year American Community Survey estimates. It is often harder for low-income families to afford products and services, such as energy efficient appliances and vehicles, which contribute to climate pollution emissions reductions due to their higher costs. It is also often harder for low-income community members to be able to take the time to participate in concerted efforts to reduce climate pollution, due to them focusing foremost on working and keeping food on the table. This GWPCAP is an opportunity to assist low-income families and communities by utilizing federal funds to help them adopt climate pollution reduction strategies without financially burdening them.



Source: 2018-2022 American Community Survey 5-year estimates

(in 2022 inflation-adjusted dollars) [xxxiii]

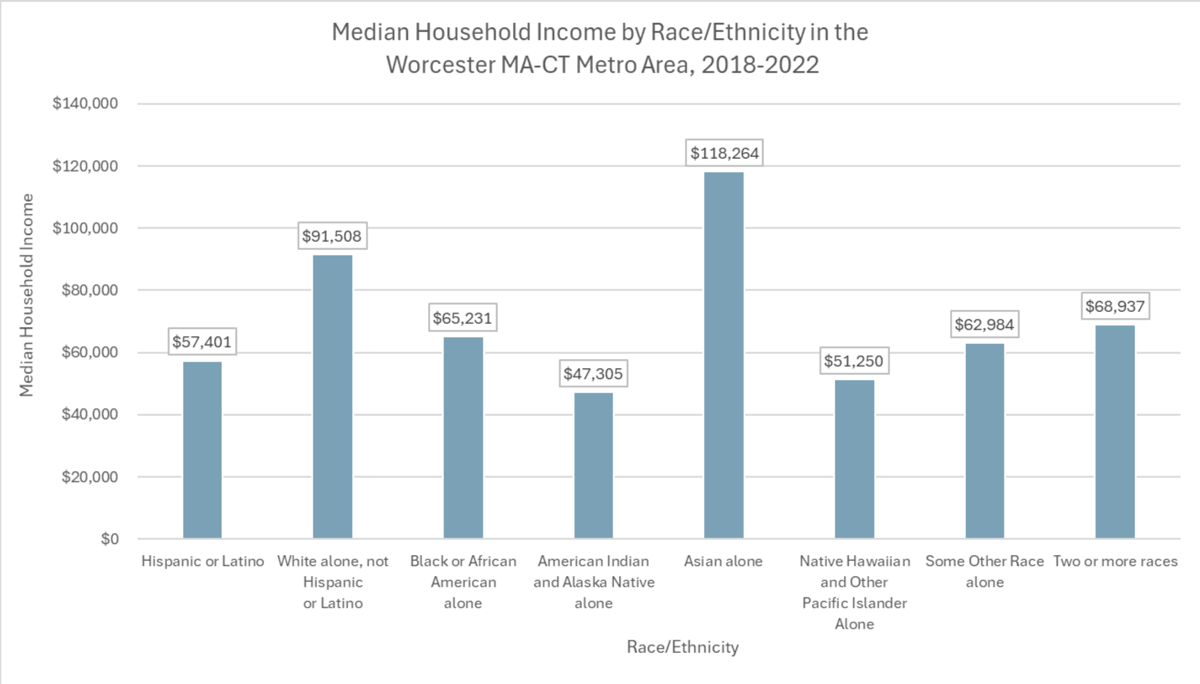
There are clear geographic disparities in median household income within the Greater Worcester region. Residents of the municipalities to the east, northeast, near northwest, and southeast of Worcester are on average more financially well-off than residents of communities in northern, far northwestern, western, and southwestern Worcester County. Residents of the downtown areas of the seven municipalities with Justice40 LIDAC Census Tracts in the region are on average more financially distressed than people living in other parts of the region.



Source: 2018-2022 American Community Survey 5-year estimates

(in 2022 inflation-adjusted dollars) [xxxiv]

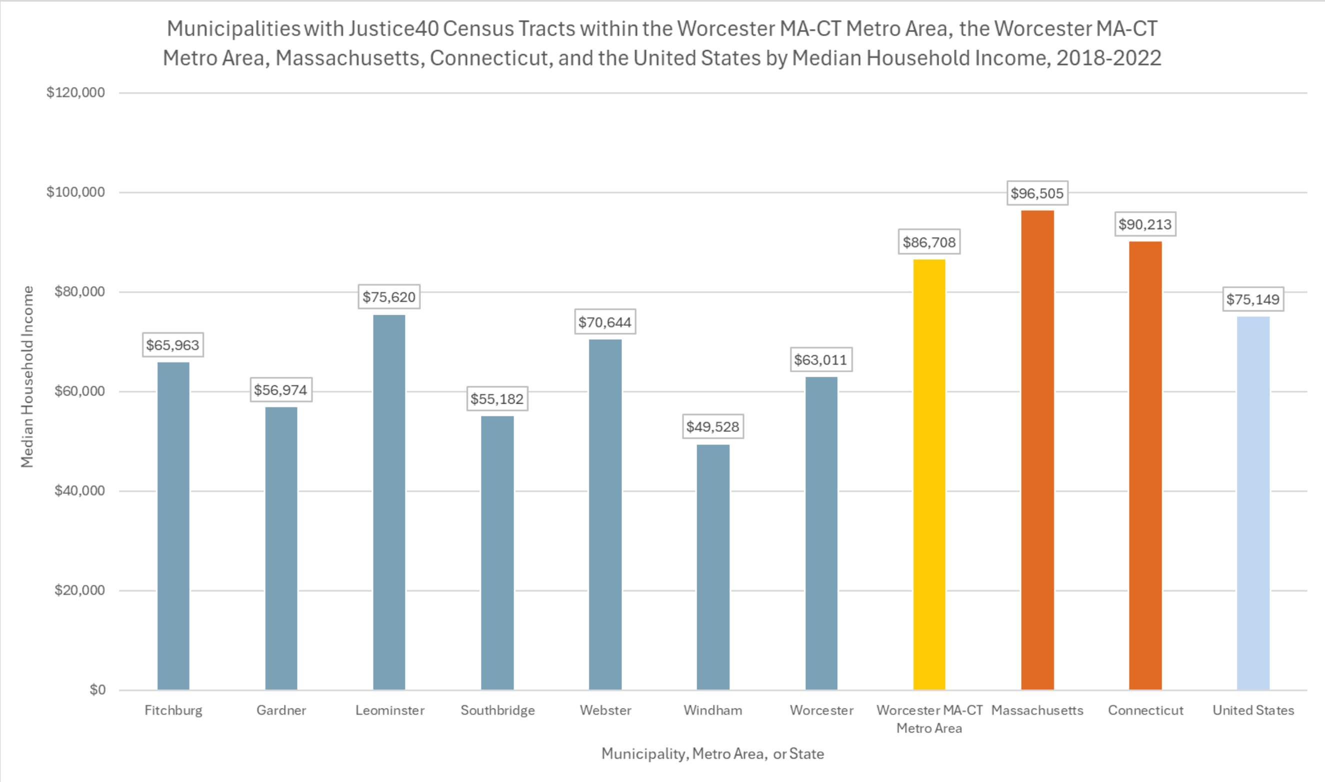
There are also clear disparities in income between residents of different racial and ethnic groups in the region. Asian and white residents have higher median household incomes than residents who have other racial / ethnic identities in the region. A major reason these disparities are so large is that members of these groups have been systemically discriminated against in housing (through processes such as redlining) and employment within the region. It is imperative for projects that stem from this GWPCAP process to have workforce, economic development, health-related, and other opportunities and co-benefits which are accessible to low-income communities, including communities of color, which have faced discrimination and exclusion.



Source: 2018-2022 American Community Survey 5-year estimates

(in 2022 inflation-adjusted dollars) [xxxv]

Although the Greater Worcester Region has a higher median household income than the United States as a whole, it has a lower median household income than either Massachusetts or Connecticut. The seven municipalities with Justice40 LIDAC Census Tracts within them all have lower median household incomes than the region, while all of them except for Leominster have lower median household incomes than the country. For this reason, in addition to the facts that these communities have high numbers of residents from historically discriminated-against racial and ethnic groups and who face air and climate pollution-related health challenges, these communities will be prioritized for several action strategies for this GWPCAP (such as those that are particularly good fits for urban communities). Individuals and institutions within these communities have on average a tough time financing projects which reduce air and climate pollution and have higher numbers of residents who are vulnerable to the localized impacts of this pollution.

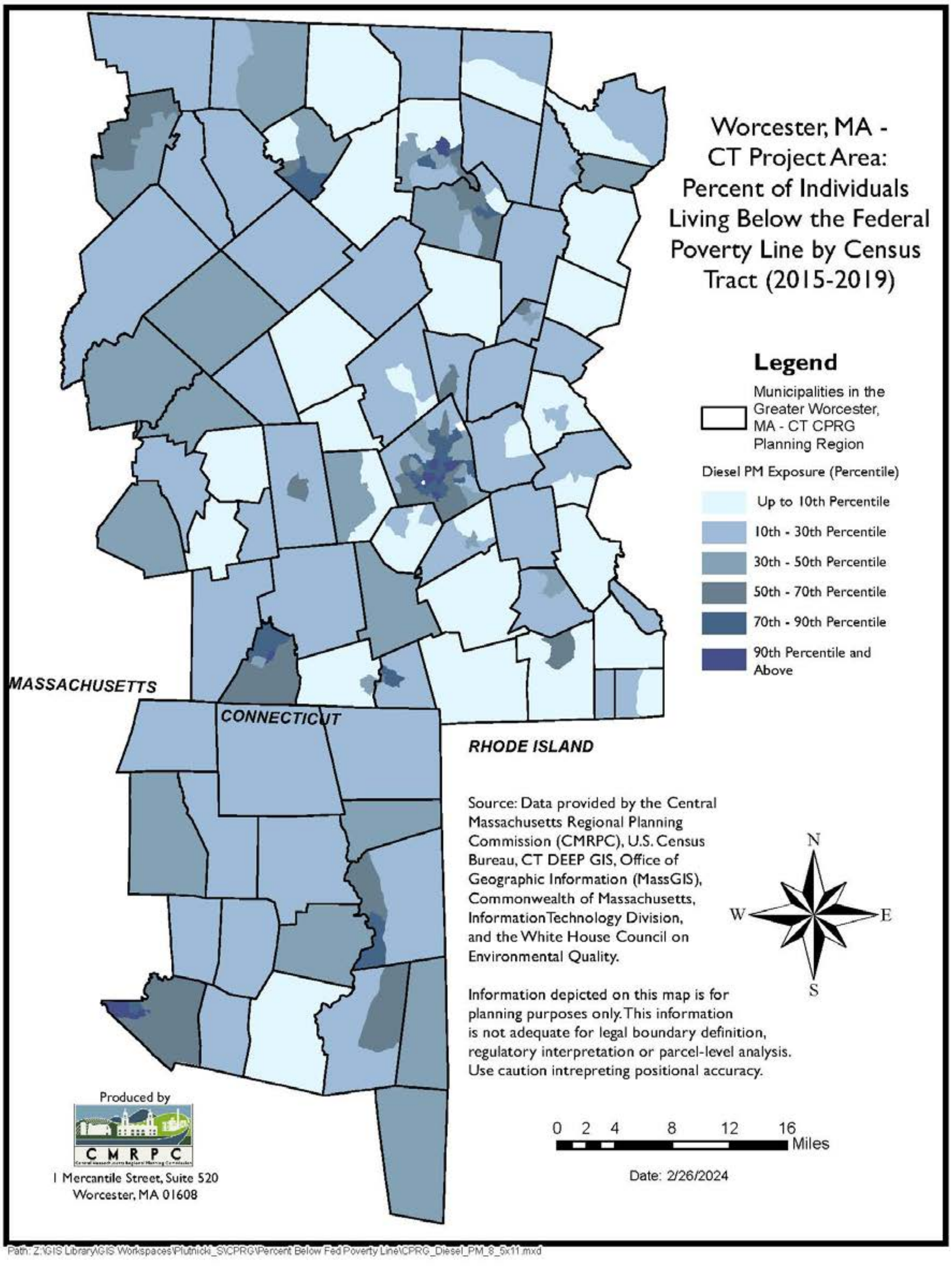


Source: 2018-2022 American Community Survey 5-year estimates

(in 2022 inflation-adjusted dollars) [xxxvi]

*Data for Windham is from 2017-2021 due to unavailability of 2018-2022 data [xxxvii]

There are also clear geographic disparities in poverty rates in the region, with the percentage of individuals living below the federal poverty line being on average higher in Justice40 LIDAC Census Tracts.[xxxviii]


Worcester, MA - CT Project Area: Percent of Individuals Living Below the Federal Poverty Line by Census Tract (2015-2019)
Legend
Municipalities in the Greater Worcester, MA - CT CPRG Planning Region
Diesel PM Exposure (Percentile)
Up to 10th Percentile
10th - 30th Percentile
30th - 50th Percentile
50th - 70th Percentile
70th - 90th Percentile
90th Percentile and Above
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
Source: Data provided by the Central Massachusetts Regional Planning Commission (CMRPC), U.S. Census Bureau, CT DEEP GIS, Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division, and the White House Council on Environmental Quality.
Information depicted on this map is for planning purposes only. This information is not adequate for legal boundary definition, regulatory interpretation or parcel-level analysis. Use caution intrepreting positional accuracy.
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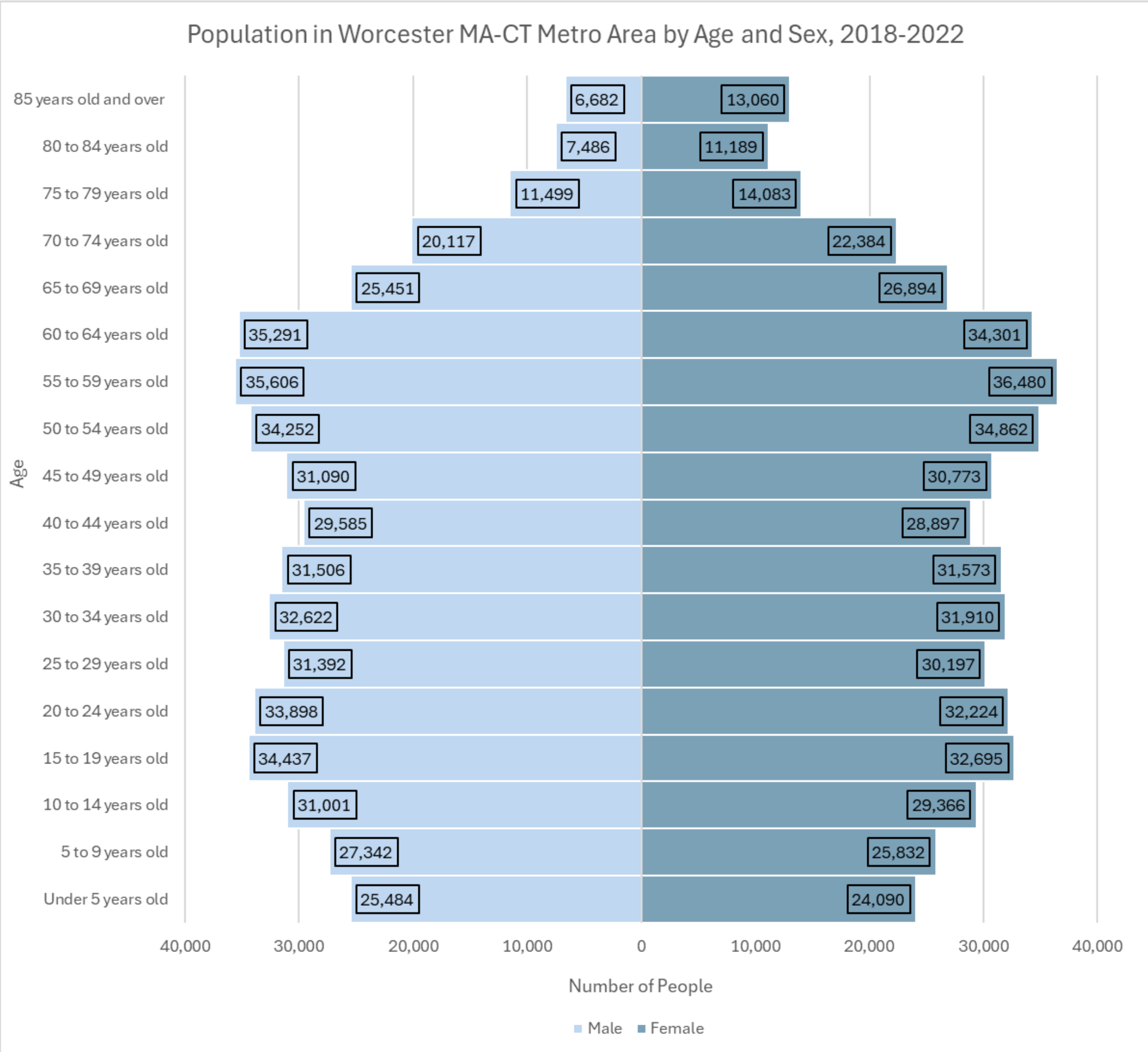
3. Age

The Greater Worcester Region has both a growing aging population and a substantial youth population. As many older adults in the region face air and climate pollution-related health challenges, it is important to include them in and consider their needs in this GWPCAP process. Many older adults, as well as other people in the region, have disabilities which may make it more difficult for them to utilize climate pollution reduction infrastructure such as bicycles and public transportation or receive information about climate pollution reduction projects. Therefore, it is important to make this infrastructure accessible to people of all abilities so that it can be fully utilized. Young people have the most to gain by preventing adverse long-term impacts of climate pollution, so they should play a key role throughout all stages of the GWPCAP process.

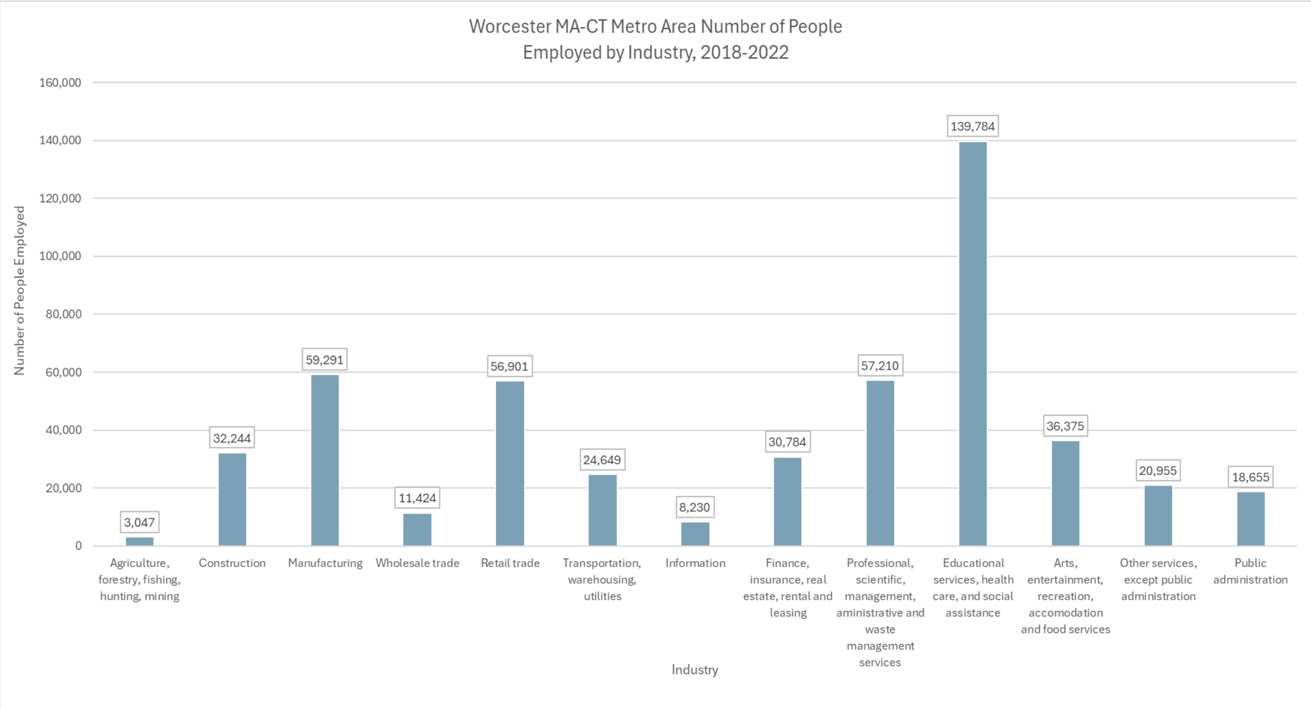


Source: 2018-2022 American Community Survey 5-year estimates [xl]

The Regional Economy

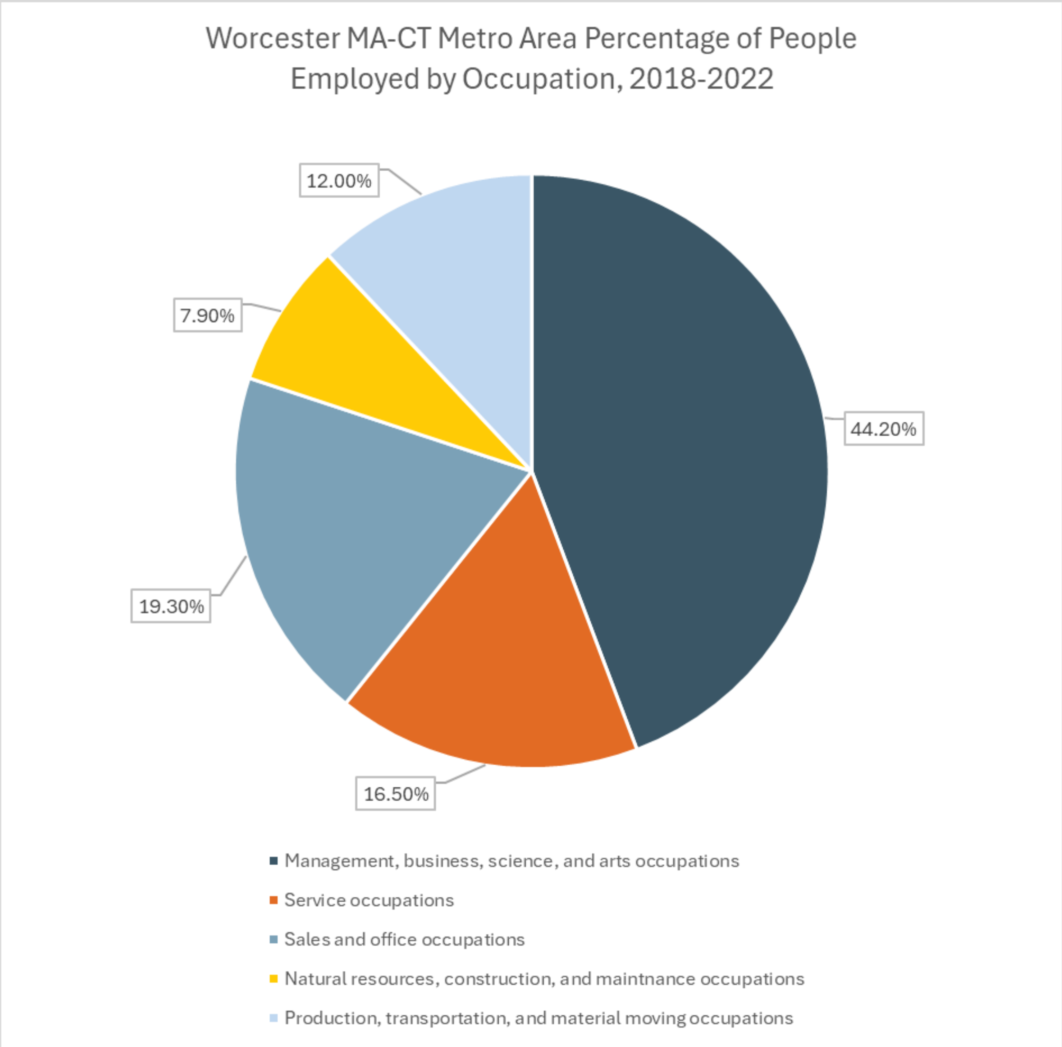
1. Major Industries

The Greater Worcester Region has a primarily service-based economy. According to 2018-2022 American Community Survey 5-year estimates, educational services, health care, and social assistance is by far the largest industry by number of people employed in the region, with almost 140,000 residents of the region working in this industry; the professional, scientific, management, administrative, and waste management services and retail trade industries are third and fourth in this ranking, respectively. There also remains a relatively important manufacturing industry in the region, with almost 60,000 residents being employed in this industry: this number places this industry second in the ranking, just above the professional, scientific, management, administrative, and waste management services and retail trade industries.



Source: 2018-2022 American Community Survey 5-year estimates [xli]

Most jobs held by Greater Worcester region residents, regardless of industry, are service-related. Approximately 45% of residents work in management, business, science, and arts occupations. Only around 12% of residents have jobs in production, transportation, and material moving, while only around 8% of residents have jobs in natural resources, construction, and maintenance.



Source: 2018-2022 American Community Survey 5-year estimates[xlii]

When considering the impact that the workforce has on emissions and potential reductions in the region, it is important to remember several key factors about the region's economy. First, the economic heart of the region is the City of Worcester, with a large cluster of businesses in its downtown. While there is public transit in the region and there is an operational train station next to the downtown servicing the City of Boston and Amtrak, most commuters are driving into the city, causing emissions from transportation. Outside of Worcester, additional economic hubs include the City of Fitchburg, the City of Leominster, and the Village of Willimantic in the Town of Windham. Second, the region has a history of industrial businesses that, while not as prevalent as in the past, drive up emissions. Third, the region has a small but historically strong contingent of farms and other agricultural practices that both drive up emissions from production and drive down emissions through carbon sequestration.

2. Major Employers

The following table lists the largest employers in the Greater Worcester region within Massachusetts and the Greater Worcester region within Connecticut, according to the Massachusetts Department of Economic Research and the Connecticut Department of Labor Office of Research, respectively:

Table 1: Worcester MA – CT Metro Area Largest Employers (2023-2024)

Company name	Address	Municipality	State	Number of employees	Industry
U Mass System Admin Ofc	Plantation St # 300	Worcester	MA	10,000+	Office Administrative Services
MSC Industrial Supply Co	Grove St	Worcester	MA	5,000-9,999	Machinery, Equipment, and Supplies Merchant Wholesalers
Community Healthlink Inc	Jaques Ave	Worcester	MA	1,000-4,999	Psychiatric and Substance Abuse Hospitals
Fallon Health	Chestnut St # 800	Worcester	MA	1,000-4,999	Other Ambulatory Health Care Services
Hanover Insurance Group Inc	Lincoln St	Worcester	MA	1,000-4,999	Agencies, Brokerages, and Other Insurance Related Activities
Integrated Genetics	Computer Dr	Westborough	MA	1,000-4,999	Architectural, Engineering, and Related Services
MAPFRE Insurance	Main St	Webster	MA	1,000-4,999	Agencies, Brokerages, and Other Insurance Related Activities
Overlook	Masonic Home Rd # 2	Charlton	MA	1,000-4,999	Specialty (except Psychiatric and Substance Abuse) Hospitals
St Vincent Hospital	Summer St	Worcester	MA	1,000-4,999	General Medical and Surgical Hospitals
St-Gobain Ceramic Materials	New Bond St	Worcester	MA	1,000-4,999	Lime and Gypsum Product Manufacturing

VNA Care Network	Thomas St	Worcester	MA	1,000-4,999	Social Advocacy Organizations
Wachusett Mountain Ski Area	Mountain Rd	Princeton	MA	1,000-4,999	Traveler Accommodation
Day Kimball Healthcare	Pomfret St	Putnam	CT	1,000-4,999	Health Maintenance Organizations

Sources: The Massachusetts Department of Economic Research and the Connecticut Department of Labor Office of Research [xliii]

The following table lists the largest manufacturing employers in the Greater Worcester region, according to these same sources. Manufacturing processes can directly and indirectly lead to elevated levels of emissions, especially in the electricity, buildings, and transportation sectors, so it will be important to work with these manufacturers during this GWPCAP process.

Table 2: Worcester MA – CT Metro Area Largest Manufacturing Employers (2023 to 2024)

Company name	Address	Municipality	State	Number of employees	Industry
St-Gobain Ceramic Materials	New Bond St	Worcester	MA	1,000-4,999	Lime and Gypsum Product Manufacturing
Flexcon Co Inc	S Spencer Rd	Spencer	MA	500-999	Plastics Product Manufacturing
Nypro Inc	Union St	Clinton	MA	500-999	Plastics Product Manufacturing
Polar Beverages Inc	Southbridge St	Worcester	MA	500-999	Beverage Manufacturing
Deluxe Corp	South St	Townsend	MA	500-999	Printing and Related Support Activities
Sterilite Corp	Scales Ln	Townsend	MA	500-999	Other Miscellaneous Manufacturing
Frito-Lay Inc	Upper Maple St	Killingly	CT	500 - 999	Potato Chip Factories (manufacturers)
Allegro Microsystems LLC	Perimeter Rd	Worcester	MA	250-499	Semiconductor and Other Electronic Component Manufacturing
David Clark Co Inc	Franklin St	Worcester	MA	250-499	Communications Equipment Manufacturing

Dexter-Russell	River St	Southbridge	MA	250-499	Cutlery and Handtool Manufacturing
Gentex Optics Inc	W Main St	Dudley	MA	250-499	Medical Equipment and Supplies Manufacturing
Lenze AC Tech	Douglas St	Uxbridge	MA	250-499	Engine, Turbine, and Power Transmission Equipment Manufacturing
United Lens Co	Worcester St	Southbridge	MA	250-499	Commercial and Service Industry Machinery Manufacturing
Vibram Corp	School St	North Brookfield	MA	250-499	Rubber Product Manufacturing
Washington Mills North Grafton	N Main St	North Grafton	MA	250-499	Other Nonmetallic Mineral Product Manufacturing
Worcester Envelope Co	Millbury St	Auburn	MA	250-499	Converted Paper Product Manufacturing
Wyman-Gordon	Worcester St	North Grafton	MA	250-499	Forging and Stamping
SMC Ltd	Independence Dr	Devens	MA	250-499	Medical Equipment and Supplies Manufacturing
Hollingsworth & Vose Co	Townsend Rd	Groton	MA	250-499	Pulp, Paper, and Paperboard Mills
United Abrasives Inc	Boston Post Rd	Windham	CT	250 - 499	Abrasive Products (manufacturers)
General Cable	Main St	Windham	CT	250 - 499	Cable (manufacturers)
SPIROL International Corp	Rock Ave	Killingly	CT	250 - 499	Screw Machine Products (manufacturers)
C&M Corp	Lake Rd	Killingly	CT	250 - 499	Cable (manufacturers)

Sources: The Massachusetts Department of Economic Research and the Connecticut Department of Labor Office of Research [xliv]

3. Major Higher Educational Institutions

The following table is a list of major higher educational institutions in the Greater Worcester Region. These institutions' current practices contribute to emissions from the electricity, transportation, buildings, and waste management sectors. They can also be important partners in the GWPCAP process.

Table 3: Major Higher Educational Institutions

Name	Location
Anna Maria College	Paxton, MA
Assumption College	Worcester, MA
Clark University	Worcester, MA
College of the Holy Cross	Worcester, MA
Eastern Connecticut State University	Windham, CT
Fitchburg State University	Fitchburg, MA
Massachusetts College of Pharmacy and Health Sciences	Worcester, MA
Mount Wachusett Community College	Gardner, MA
Nichols College	Dudley, MA
Quinebaug Valley Community College	Killingly, CT
Quinsigamond Community College	Worcester, MA
Tufts University School of Veterinary Medicine	Grafton, MA
UMass Chan Medical School	Worcester, MA
Worcester Polytechnic Institute	Worcester, MA
Worcester State University	Worcester, MA

Sources: Connecticut.gov Colleges and Universities Map and

MassGIS Data on Colleges and Universities [xlv]

4. Major Healthcare Institutions

The following table is a list of major acute care healthcare institutions in the Greater Worcester Region. These institutions' current practices contribute to emissions from the electricity, transportation, buildings, and waste management sectors. They can also be important partners in the GWPCAP process.

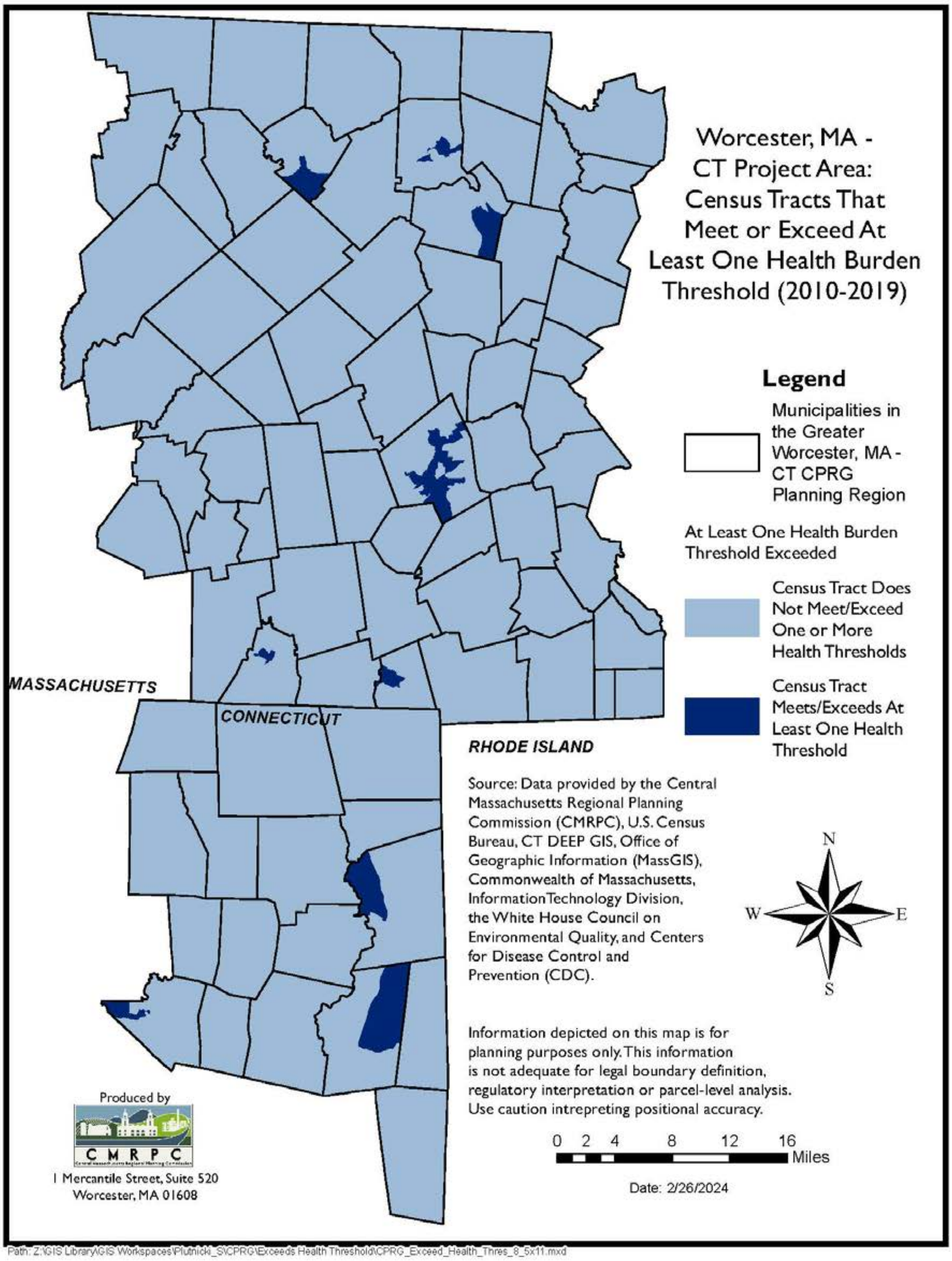
Table 4: Major Healthcare Institutions

Name	Location
Athol Hospital	Athol, MA
Day Kimball Hospital	Putnam, CT
Harrington Memorial Hospital	Southbridge, MA
HealthAlliance – Clinton Hospital	Clinton, MA
HealthAlliance Hospital – Leominster Campus	Leominster, MA
Heywood Memorial Hospital	Gardner, MA
Nashoba Valley Medical Center	Ayer, MA
UMass Memorial Medical Center – Memorial Campus	Worcester, MA
UMass Memorial Medical Center – University Campus	Worcester, MA
Saint Vincent Hospital	Worcester, MA
Windham Community Memorial Hospital	Windham, CT

Sources: CT Healthcare Explained and

MassGIS Data on Acute Care Hospitals [xlvi]

Health Disparities



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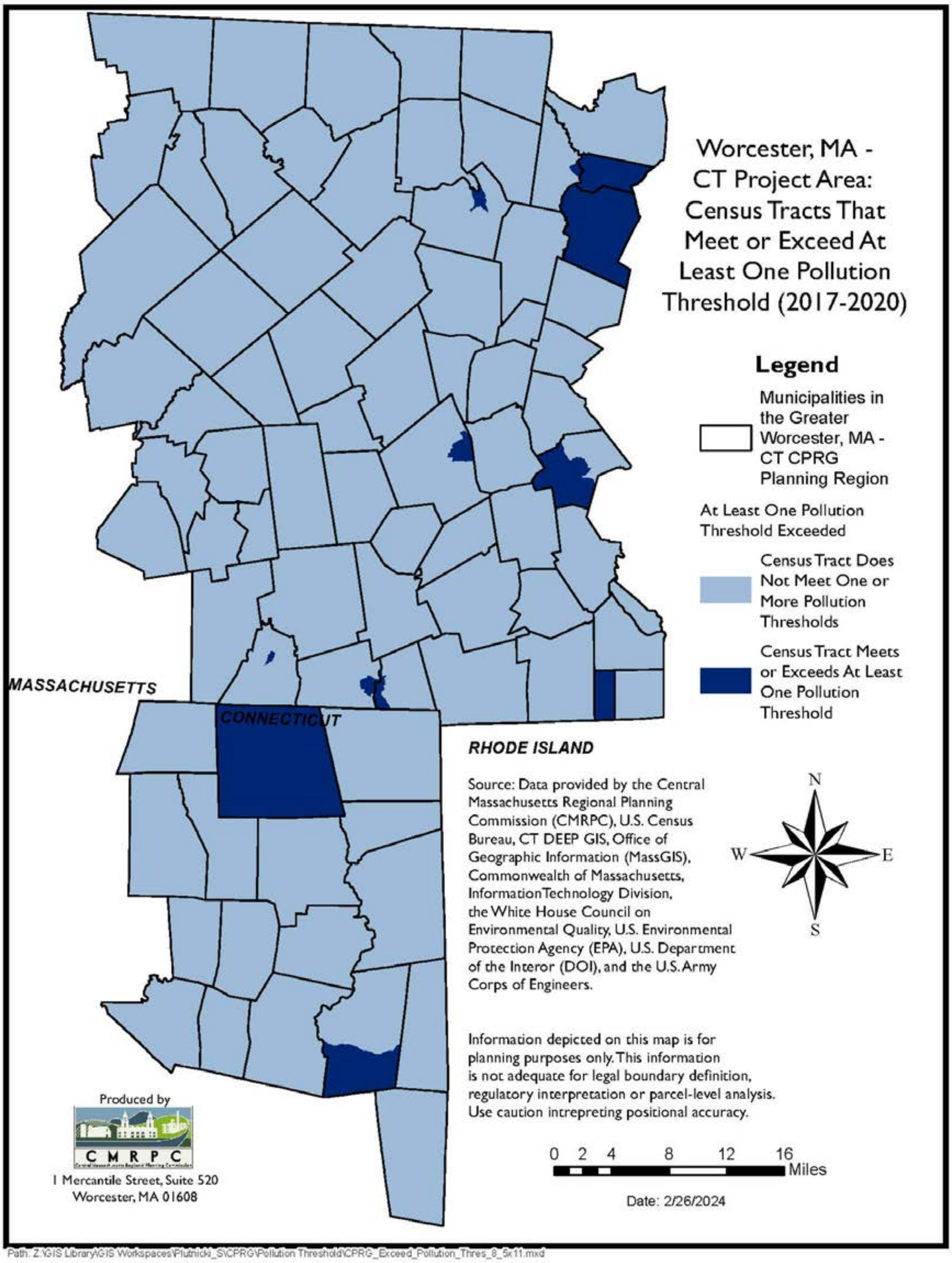
xlvii

Dark blue Census tracts on this map meet or exceed at least one CEJST Health Burden Threshold.[xlviii] These thresholds are at the 90th percentile in the country for asthma, diabetes, heart disease, and low life expectancy. In Massachusetts, these dark blue areas are in central Worcester, southeast Leominster, central Fitchburg, and part of Webster and Southbridge. In Connecticut, census tracts that exceed this threshold are found in Killingly and Plainfield. The remaining towns on the map represented in the light blue color are areas that do not meet or exceed the One Health Burden threshold. This shows an overlapping trend between health burdens with Justice40 LIDAC Census Tracts.

The Adverse Impacts of Pollution



xlix

Dark blue Census tracts on this map meet or exceed at least one CEJST Pollution Threshold. These thresholds are at least one abandoned mine, at least one formerly used defense site, and at the 90th percentile in the country for proximity to hazardous waste facilities, proximity to Superfund sites, and proximity to Risk Management Plan

(RMP) facilities.[l] In Massachusetts, these dark blue areas are in Ayer, eastern Worcester, Millville, Westborough, and on the Webster and Dudley line. In Connecticut, census tracts that exceed this threshold are found in Woodstock and Plainfield. The remaining towns on the map represented in the light blue color are areas that do not meet or exceed the One Pollution Threshold. This shows an overlapping trend between pollution contamination and Justice40 LIDAC Census Tracts.

Energy Production, Distribution, and Use Within the Region

1. New England's Electrical Grid

The electrical grid in New England is operated by an Independent System Operator (ISO). ISO New England is a nonprofit, independent transmission organization that manages the interconnection, prices, and reliability of the electrical grid between Massachusetts, Connecticut, Maine, Rhode Island, Vermont, and New Hampshire.[li] CMRPC met with ISO New England during this planning process, to ensure each of our goals and strategies were feasible, effective, and aligned with their work.

According to data from ISO New England, the New England's electricity is powered by primarily natural gas and nuclear energy. Table 5 below shows the energy sources powering New England's electrical grid. Table 6 below shows the renewable energy sources that make up the 17% of New England's electricity sourced from renewables.

Table 5: New England Electrical Grid Energy Sources

Resource	Percent
Natural gas	39%
Nuclear	28%
Renewables	17%
Hydro	8%
Net Imports	8%
Other	<1%

Table 6: New England Renewable Energy Sources Used in the Electrical Grid

Resource	Percent
Wind	55%
Solar	19%
Refuse	13%
Wood	11%
Landfill gas	2%

Source for both tables: Independent Service Operator (ISO) New England[lii]

In New England, more than 350 energy-generating plants are responsible for turning these resources into electricity. These bulk energy suppliers than sell produced electricity to wholesale electricity markets, utilities, or other competitive suppliers. Transmission lines and transformers are then utilized to distribute the electricity from the power plants to distribution lines. The distribution lines then connect to 7 million retail electricity customers across New England (homes, businesses, and other buildings.)[liii]

2. Massachusetts and Connecticut Building Heat

Coupled with electricity, New England still relies on natural gas and oil for building heat. In Massachusetts, most homes and other buildings are heated with natural gas. In the state, all natural gas for building heat comes from wells. These wells are mainly located to the north in Canada, and to the south in the southern United States. The gas then flows from these wells to buildings in Massachusetts through pipelines. There are around 1,000 miles of natural gas transmission lines running through Massachusetts. The state also uses liquefied natural gas (LNG) during the winter when heat demand is exceedingly high. LNG is mainly shipped from Trinidad and Algeria to the Distrigas terminal in Everett, Massachusetts. Natural gas and LNG transmission company's pipelines then connect to the meters of the localized distribution system run by seven local distribution companies and four Municipal Gas Departments in the state. From there, mains and services connect the distribution system to buildings across the state.[liv]

In Connecticut, on the other hand, most homes and other buildings are heated with oil. In the state, 42% of homes get heat from oil, compared to just 5% of buildings heated with oil in the United States as a whole. Derived from crude oil, heating oil heats homes through oil tanks, filter, fuel pump, thermostat, or combustion chamber. Connecticut homeowners and landlords using oil heat for space heating or water heating must purchase enough oil for the winter months in advance. This oil fuel is then combusted in a combustion chamber safely contained within each building heating unit.[lv]

Climate Change Projections for the Region

Massachusetts:

Temperature**:** According to the Massachusetts Climate Assessment in 2022, Massachusetts has experienced a 3.5°F increase in average annual temperatures since 1900. Future climate projections show an overall expected increase in average temperature for most of Massachusetts, with Eastern and Central Massachusetts likely seeing the greatest rise in average temperature by 2050. Central Massachusetts could see average temperatures rise between 5.4-6.3°F by 2050.[lvi] The current statewide average temperature, provided by the NOAA (National Oceanic and Atmospheric), is 50.3°F but varies by region. Historically, temperatures are lower in Western Massachusetts and higher in the East. An increase in average annual temperatures means more intense summers with more frequent heat waves. Warmer temperatures are connected to impaired human health, increased incidence of drought, reduced agriculture yields, species range shifts, and damaged infrastructure.[lvii]

Precipitation: The Massachusetts Climate Assessment in 2022 shows an overall statewide increase in precipitation by 2070, but seasonal patterns will vary drastically. Central Massachusetts could see annual precipitation increases ranging from 0-24% by 2070.[lviii] Due to higher temperatures, the moisture holding capacity of the atmosphere increases, causing greater variety in precipitation patterns.[lix] Central Massachusetts is especially vulnerable to climate hazards associated with varying precipitation patterns. By the mid-century, the annual river flood chance could be two times more likely within Central Massachusetts, increasing the chance of dam failures and flooding in downstream areas. [lx] Dam failure is a concerning hazard in Central Massachusetts. Based on MassGIS data, Central Massachusetts currently has 104 "High Hazard" dams and 250" Significant Hazard" dams in the region. The combination of increased precipitation and low-quality dams could lead to disastrous flooding causing property damage and severe injury or death.

Northeast Connecticut

Temperature: Average temperatures in Connecticut are projected to increase by 5°F by 2050 compared to the 1970-1999 baseline.[lxi] Additionally, the number of days above 90°F are expected to increase from an average of 5 days to an average of 25 days by 2050. These projections show an increased risk of drought and major flooding in Connecticut. Droughts will affect the agriculture industry in Northeast Connecticut and town water needs in rural areas. The region could be forced to place restrictions on public, commercial, or industrial water consumption. In extreme cases, wildfires could occur in the region if current emissions trend continues in the future.[lxii]

Precipitation: According to the Connecticut Institute for Resilience & Climate Adaptation (CIRCA), annual total precipitation across the state and the NECCOG planning region is projected to increase by 4-5 inches (~8.5%) by the midcentury (2040-2069) and by 4.5-5.5 inches (~10%) by the late century (2070-2099).[lxiii] The CT Governor's Council on Climate Change CG3 Phase 1 Report predicts less snow and more rain due to the increase of moisture capacity in the atmosphere and warmer temperatures.[lxiv] Additionally, flooding is common in Northeastern Connecticut due to the abundance of rivers in the region. Due to the development patterns near rivers, flooding is one of the major hazards in Northeast Connecticut. [lxv] Flooding can affect the entire region and cause significant property damage and possibly injuries or death. The NECCOG region contains 9 "High Hazard" dams and 28 "Significant Hazard" dams with hundreds of smaller dams. Increased precipitation can cause higher rates of dam failures that result in sudden and severe onset flooding.[lxvi]

Important Organizations and Stakeholders in the Region

Connecticut Department of Agriculture (DOAG): The Connecticut Department of Agriculture's (DOAG) mission is to sustain and grow Connecticut agriculture. The Department preserves working lands and ensures they are available for agricultural use in perpetuity.[lxvii]

Connecticut Department of Energy and Environmental Protection (CT DEEP): The Connecticut Department of Energy and Environmental Protection (CT DEEP) is charged with conserving, improving, and protecting natural resources and the environment. CT DEEP also works to make energy cheaper, cleaner, and more dependable. [lxviii]

Connecticut Department of Housing: The Connecticut Department of Housing is dedicated to ensuring that all Connecticut residents have access to high-quality housing options. The Department also recognizes that severe weather threatens homes throughout the state and plans for mitigation and resiliency programs.[lxix]

Connecticut Department of Transportation (CTDOT): The Connecticut Department of Transportation (CTDOT) is responsible for the development and operation of highways, railroads, transit systems, ports, and waterways throughout the state. [lxx]

ISO New England: An independent, not-for-profit corporation authorized by the Federal Energy Regulatory Commission (FERC) responsible for keeping electricity flowing across New England. Their vision includes "harnessing the power of competition and advanced technologies to reliably plan and operate the grid as the region transitions to clean energy". They will be critical to transitioning to clean energy that reduces climate emissions.[lxxi]

Local Land Trusts: Local land trusts are local, regional, or state non-profits dedicated to fostering land and natural resources. Some land trusts near and within the Region include the Metacomet Land Trust, Grafton Land Trust, Greater Worcester Land Trust, Mass Audubon, and the Trustees of Reservations. [lxxii]

Massachusetts Department of Agricultural Resources (MDAR): The Massachusetts Department of Agricultural Resources (MDAR) is dedicated to promoting a vibrant, equitable and resilient agricultural economy.[lxxiii]

Massachusetts Department of Conservation and Recreation (DCR): The Massachusetts Department of Conservation and Recreation works to protect, promote and enhance the state's natural, cultural and recreational resources. MA DCR manages state parks and conservation land. [lxxiv]

Massachusetts Division of Conservation Services (MA DCS): The Massachusetts Division of Conservation Services offers grants to municipalities and non-profits for the acquisition of conservation and parkland and parkland development and renovation. MA DCS also administers Conservation Restriction (CRs) and the Conservation Land Tax Credit (CLTC). [lxxv]

Massachusetts Department of Energy Resources (MA DOER): The Massachusetts Department of Energy Resources helps to create a clean, affordable equitable and resilient energy future for the state. [lxxvi]

Massachusetts Department of Environmental Protection (MA DEP): The Massachusetts Department of Environmental Protection (MassDEP) works to enhance and protect the state's air, water, and land. Additionally, MassDEP works to advance environmental justice and equity while promoting opportunities for workforce development. [lxxvii]

Massachusetts Executive Office of Housing and Livable Communities (MA EOHLC): The Massachusetts Executive Office of Housing and Livable Communities (MA EOHLC) was established to create more homes and lower housing costs for Massachusetts residents. MA EOHLC distributes funding to municipalities and operates the state's Emergency Family Shelter (EA) program. [lxxviii]

Massachusetts Department of Transportation (MassDOT): The Massachusetts Department of Transportation (MassDOT) oversees roads, public transit, aeronautics, and transportation licensing and registration in the state. MassDOT also works closely with the state's transit authorities and Regional Planning Agencies (RPAs). [lxxix]

MassBike: The Massachusetts Bicycle Coalition, or MassBike, is a statewide bicycle advocacy group. MassBike's mission it "to make bicycling part of human-centered communities, policies, culture, and infrastructure." MassBike also operates an E-Bike program, where income-qualifying residents from Worcester and the surrounding communities may be chosen to receive a free E-Bike. [lxxx]

Mass Save: Mass Save is a collaborative of Massachusetts' electric and natural gas utilities and energy efficiency service providers. They empower residents, businesses, and communities to scale-up their energy efficiency by offering a range of services, rebates, incentives, and more. [lxxxi]

Montachusett Regional Planning Commission (MRPC): The MRPC is the Regional Planning Agency for the towns in greater north central Massachusetts. MRPC carries out a variety of projects for the municipalities in their region, from transportation planning to comprehensive planning.[lxxxii]

Montachusett Regional Transit Authority (MART): The Montachusett Regional Transit Authority (MART) is a public, non-profit organization that provides public transportation to towns in north central Massachusetts, including Gardner, Leominster, and Fitchburg. [lxxxiii]

Municipal Entities: Please see the map in this Plan's Background Section to see all relevant municipal entities to this project area.

Municipal Light Plants (MLPs): Facilities owned and operated by a municipality to provide electric and/or gas services to residents of that town. [lxxxiv]

North County Climate Coalition (NC4): NC4 is comprised of municipal and civic leaders across Massachusetts Congressional District 3 working on the frontlines of climate change resistance, resilience, and adaptation. NC4 strengthens regional collaborative efforts to combat climate change. [lxxxv]

Northeastern Connecticut Council of Governments (NECCOG): NECCOG is a chief-elected forum for the member towns of Northeast Connecticut to discuss, facilitate, and develop responses to issues of mutual concern. This organization can assist climate pollution reduction efforts for their region's towns. [lxxxvi]

Northeast Connecticut Transit District (NECTD): The Northeast Connecticut Transit District (NECTD) is a public, non-profit transportation provider for eleven towns in northeastern Connecticut: Brookly, Canterbury, Hampton, Killingly, Putnam, Thompson, Eastford, Plainfield, Pomfret, Woodstock, and Union. [lxxxvii]

Regional Environmental Council (REC): The Regional Environmental Council (REC) is a grassroots non-profit food justice organization based in the city of Worcester. Their programs include community and school gardens, farmers markets, and YouthGROW, a youth employment and urban agriculture program for Worcester teenagers. [lxxxviii]

WalkBike Worcester: WalkBike Worcester is a citizen advocacy group that would like to see the streets of Worcester become safer, more convenient and pleasant for all users. WalkBike Worcester is a part of the WalkMassachusetts network. [lxxxix]

WalkMassachusetts: WalkMassachusetts (previously WalkBoston) works to improve walkability across Massachusetts in many ways, such as through community organized walk audits. Their goal is to build local constituencies to advocate for walkability.[xc]

Watershed-Based Organizations: Organizations such as the Blackstone Watershed Association, Nashua River Watershed Association, Thames River Watershed Association are all non-profit organizations that value watershed-based resiliency planning and work to support healthy watersheds.

Worcester Community Action Council (WCAC): Worcester Community Action Council is one of 1,000 community action agencies across the United States and one of 23 in Massachusetts. The WCAC's mission is to break the cycle of poverty, one neighbor at a time. The WCAC also has contracts with the MA Department of Energy and major local utilities to install energy conservation measures in low-income homes throughout central and southern Worcester County. [xci]

Worcester County Conservation District (WCCD): WCCD is a division of the state government that provides local leadership in the conservation of natural resources for farmers and forest landowners. WCCD provides guidance for federal financial aid and technical assistance to landowners for conservation planning. [xcii]

Worcester Regional Transit Authority (WRTA): The Worcester Regional Transit Authority (WRTA) is a public, non-profit organization that provides public transportation to the city of Worcester, Massachusetts and the surrounding towns.[xciii]

Windham Region Transit District (WRTD): The Windham Region Transit District is a public, non-profit organization that provides public transportation to Windham, Connecticut and the surrounding towns, including Chaplin and Scotland.[xciv]

Ongoing Planning Efforts – Worcester County & Eastern Connecticut

Related to climate pollution reduction efforts in the Greater Worcester Region, Towns, Cities, and Regional Entities are busy working on a variety of planning efforts to make the region a more resilient and sustainable place. In Massachusetts, most communities take part in a program known as Green Communities. Once municipalities go through a designation process, Green Communities offers those communities financial assistance to implement energy efficiency projects in municipal buildings and can offer some financial assistance for fleet efficiency upgrades. Also in Massachusetts, communities can go through a planning process known as the Municipal Vulnerable Preparedness (MVP) Program that creates nature-based solutions to protect important infrastructure, environmental, and societal features against natural hazards resulting from climate change. Once the communities have completed this process, they are eligible to apply for action grants that would implement the strategies. All Massachusetts communities also go through a planning process every seven years to update their Open Space and Recreation Plans which look at how land is used and protected for recreation and conservation purposes. In both Connecticut and Massachusetts, municipalities are required to have current Hazard Mitigation Plans to receive funds from FEMA (Federal Emergency Management Agency) if a natural disaster declaration is announced. In Connecticut, NECCOG, work is planned to create a regional facility to collect household hazardous waste year-round and promote more responsible disposal of those products that would otherwise be put in the mainstream trash. Finally, the Towns of Harvard, Princeton, Westborough, Shrewsbury, and the City of Worcester have undergone town specific climate action plans; these plans were considered in the creation of this regional climate action plan.

Low-Income and Disadvantaged Communities

The federal government recognizes that climate pollution and climate change places a disproportionate burden on the nation's low-income and disadvantaged populations. The Justice 40 Initiative represents the government's commitment to directing 40% of federal funds related to climate and clean energy towards programs, projects, and actions that directly benefit disadvantaged populations.[xcv] This program includes investments in clean transit, sustainable housing, and workforce development. The Climate Pollution Reduction Grant (CPRG) is recognized as one of these federal grant programs that requires 40% of investments be directed towards disadvantaged populations.

For the purposes of GWPCAP planning process, CMRPC has utilized two standards for identifying communities that are excessively vulnerable to climate risks and that experience socioeconomic challenges: the United States Climate and Economic Justice Screening Tool (CJEST) and state designated Environmental Justice populations. Specifically, CMRPC has utilized CJEST to identify federally designated low-income and disadvantaged communities (LIDACs), also known as Justice 40 communities.[xcvi] Massachusetts and Connecticut Environmental Justice communities were identified in addition to Justice 40 communities as a means of expanding this Plan's reach and applicability.[xcvii] Both LIDACs and state EJs were acknowledged and considered throughout the engagement and development of the GWPCAP.

The following table includes all federally recognized low-income and disadvantaged Census Tracts within the Greater Worcester, MA-CT MSA CPRG Planning Region. The specific climate and economic factors that burden each of these Census Tracts are listed in the right-hand column. Both the Census Tracts and each of their respective burdens were identified using CJEST. Each Census Tract is considered disadvantaged if it meets one burden threshold and the associated socioeconomic threshold.[xcviii] For example, if a community meets the threshold for the asthma burden but not the associated low-income burden, it may not be considered a LIDAC. The threshold for all but two of the CJEST burden factors is the 90th percentile, meaning that the identified Census Tract is within the top 10% most burdened areas within that specific factor.

The "low income" burden identifies people in households where income is less than or equal to twice the federal poverty level, not including students enrolled in higher education. The threshold for the low-income burden is the 65th percentile. The low-income burden is the associated socioeconomic factor for seven of the eight categories of burden used for CJEST: climate change, energy, health, housing, legacy pollution, transportation, waste and wastewater. This means if a Census Tract is identified as burdened by low income and by any of the factors within these seven categories, it is considered an LIDAC. It is worth emphasizing that any Census Tract may be considered burdened by any of the factors within each category; however, if one does not also meet the associated socioeconomic threshold, it may not be considered as a LIDAC. The eighth category of burden is workforce development and the associated socioeconomic factor for this category is high school education. The "high school education" burden identifies the percent of people within the Census Tract that are ages 25 or older whose high school education is less than a high school diploma. The threshold for the high school education burden is above 10% of the population. If a Census Tract is identified as burdened by the high school education factor and any of the other factors within the workforce development category, it may be considered as a LIDAC.

Table 7: Greater Worcester Region Low-Income and Disadvantaged Communities (LIDACs)

LIDAC	Census Tract	Identified Burdens
Fitchburg, MA	7105	Asthma, unemployment, low income, high school education
Fitchburg, MA	7107	Low income, energy cost, asthma, lack of green space, traffic proximity and volume, linguistic isolation, low median income, poverty, high school education
Fitchburg, MA	7108	Asthma, low income, housing cost, lead paint, low median income, poverty, unemployment, high school education
Fitchburg, MA	7110	Asthma, unemployment, high school education
Gardner, MA	7071	Asthma, low income, high school education
Gardner, MA	7072	Asthma, low income, energy cost, heart disease, housing cost, lack of green space, lead paint, low median income, poverty, high school education
Leominster, MA	7092	Asthma, low income, lack of indoor plumbing, high school education
Leominster, MA	7094	Energy cost, low income, asthma, unemployment, high school education
Leominster, MA	7096	Proximity to hazardous waste facilities, traffic proximity and volume, low income, high school education
Southbridge, MA	7571	Unemployment, low income, high school education
Southbridge, MA	7572	Projected flood risk, low income, energy cost, asthma, housing cost, lead paint, proximity to hazardous waste facilities, low median income, poverty, high school education
Southbridge, MA	7573	Low income, energy cost, asthma, lack of indoor plumbing, lead paint, linguistic

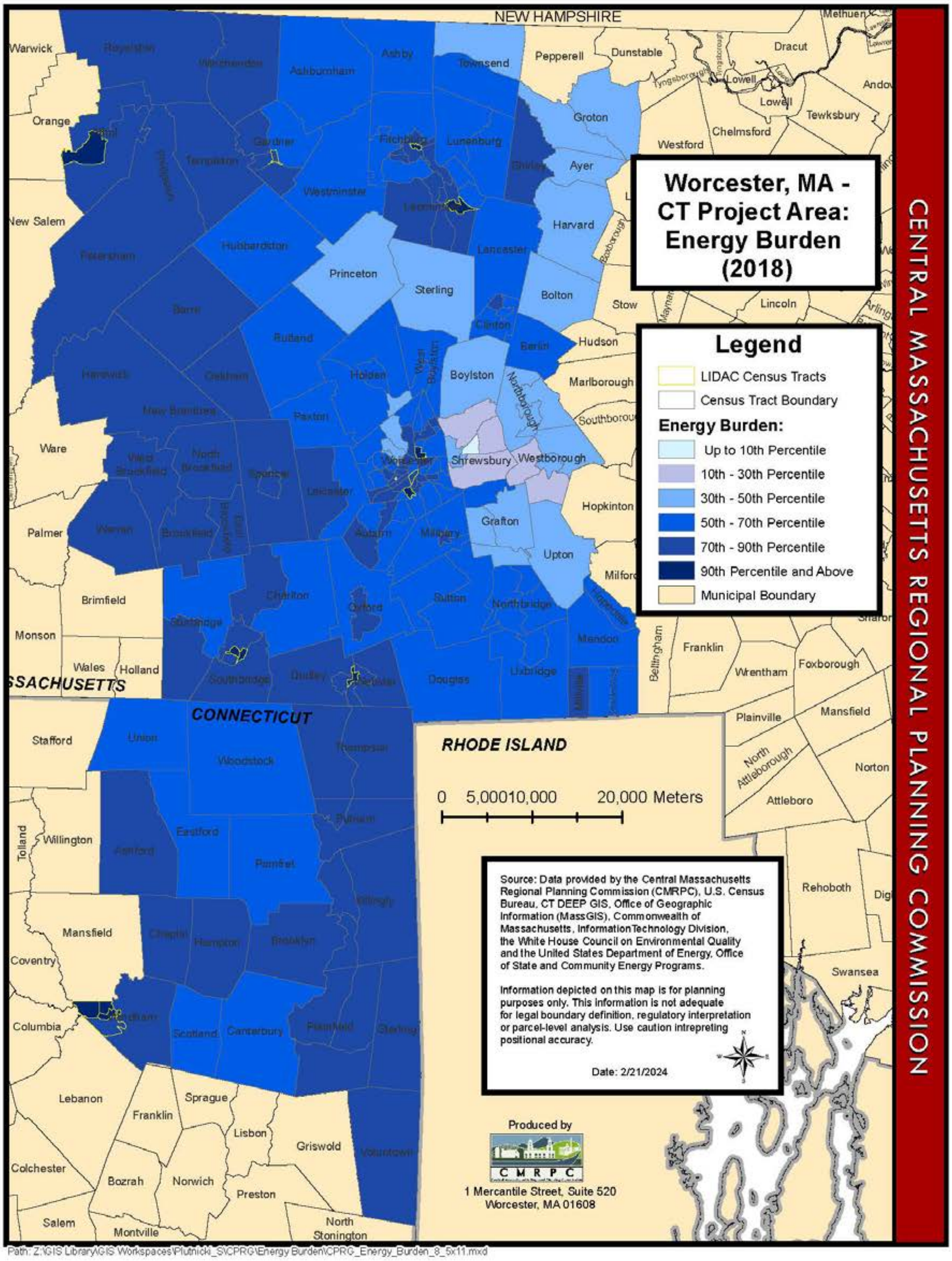
		isolation, low median income, high school education
Webster, MA	7542	Asthma, low income, high school education
Webster, MA	7543	Energy cost, low income, asthma, housing cost, lead paint, proximity to risk management facilities, low median income, high school education
Windham, CT	8003	Energy cost, asthma, housing cost, lack of indoor plumbing, linguistic isolation, low median income, poverty, high school education
Windham, CT	8005	Transportation barriers, low income, high school education
Windham, CT	8006	Low income, energy cost, asthma, housing cost, lead paint, linguistic isolation, low median income, poverty, unemployment, high school education
Worcester, MA	7304	Asthma, low income, traffic proximity and volume, linguistic isolation, high school education
Worcester, MA	7305	Asthma, low income, lead paint, traffic proximity and volume, high school education
Worcester, MA	7311	Asthma, low income, housing cost, lead paint, high school education
Worcester, MA	7312	Asthma, low income, lack of green space, lack of indoor plumbing, lead paint, traffic proximity and volume, linguistic isolation, low median income, poverty, high school education
Worcester, MA	7313	Asthma, low income, housing cost, lack of green space, lack of indoor plumbing, lead paint, traffic proximity and volume, linguistic isolation, low median income, poverty, high school education
Worcester, MA	7314	Low income, asthma, housing cost, lack of green space, lead paint, traffic proximity

		and volume, linguistic isolation, low median income, poverty, high school education
Worcester, MA	7315	Low income, asthma, housing cost, lack of green space, lead paint, linguistic isolation, low median income, high school education
Worcester, MA	7316	Asthma, housing cost, lack of green space, lack of indoor plumbing, lead paint, traffic proximity and volume, low median income, poverty, high school education
Worcester, MA	7317	Housing cost, low income, lack of green space, lack of indoor plumbing, traffic proximity and volume, linguistic isolation, low median income, high school education
Worcester, MA	7318	Low income, asthma, housing cost, lack of green space, lack of indoor plumbing, traffic proximity and volume, linguistic isolation, low median income, poverty, high school education
Worcester, MA	7319	Energy cost, low income, asthma, housing cost, lack of green space, lead paint, traffic proximity and volume, linguistic isolation, low median income, unemployment, high school education
Worcester, MA	7320	Low income, asthma, housing cost, linguistic isolation, low median income, poverty, unemployment, high school education
Worcester, MA	7322	Linguistic isolation, traffic proximity and volume, high school education, housing cost, lack of green space
Worcester, MA	7323	Asthma, low income, underground storage tanks and releases, linguistic isolation, high school education
Worcester, MA	7324	Asthma, low income, low life expectancy, housing cost, lack of green space, lead

		paint, traffic proximity and volume, linguistic isolation, high school education
Worcester, MA	7325	Expected population loss rate, projected flood risk, low income, energy cost, asthma, low life expectancy, housing cost, lack of green space, lack of indoor plumbing, lead paint, traffic proximity and volume, low median income, poverty, high school education
Worcester, MA	7326	Asthma, low income, housing cost, lack of green space, lead paint, traffic proximity and volume, high school education
Worcester, MA	7327	Asthma, low income, housing cost, lead paint, low median income, high school education
Worcester, MA	7330	Projected flood risk, low income, asthma, housing cost, lead paint, traffic proximity and volume, low median income, high school education

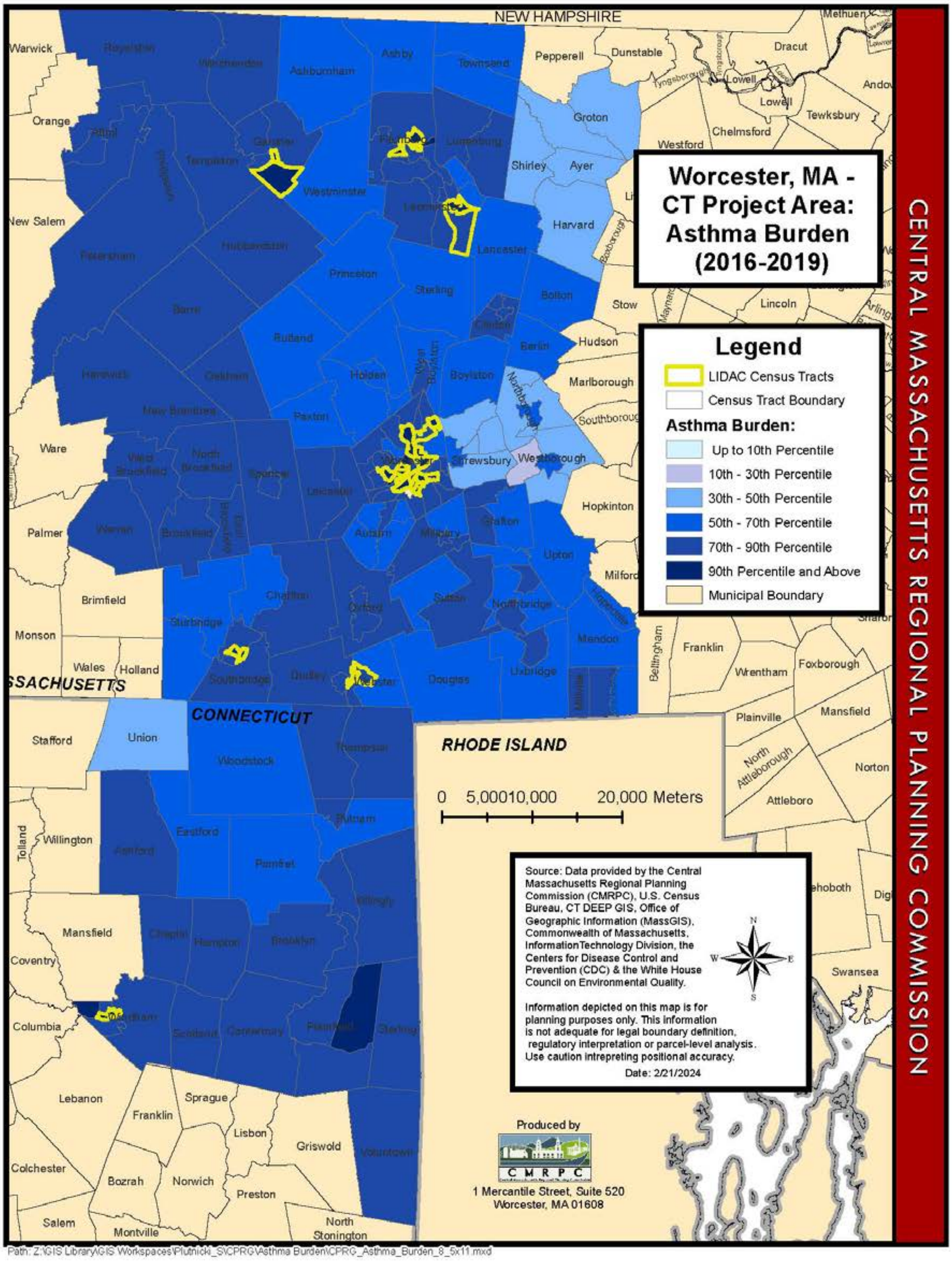
Source: United States Climate and Economic Justice Screening Tool (CEJST)[xcix]

All the LIDAC maps below have been created using data from the following CEJST website.[c]



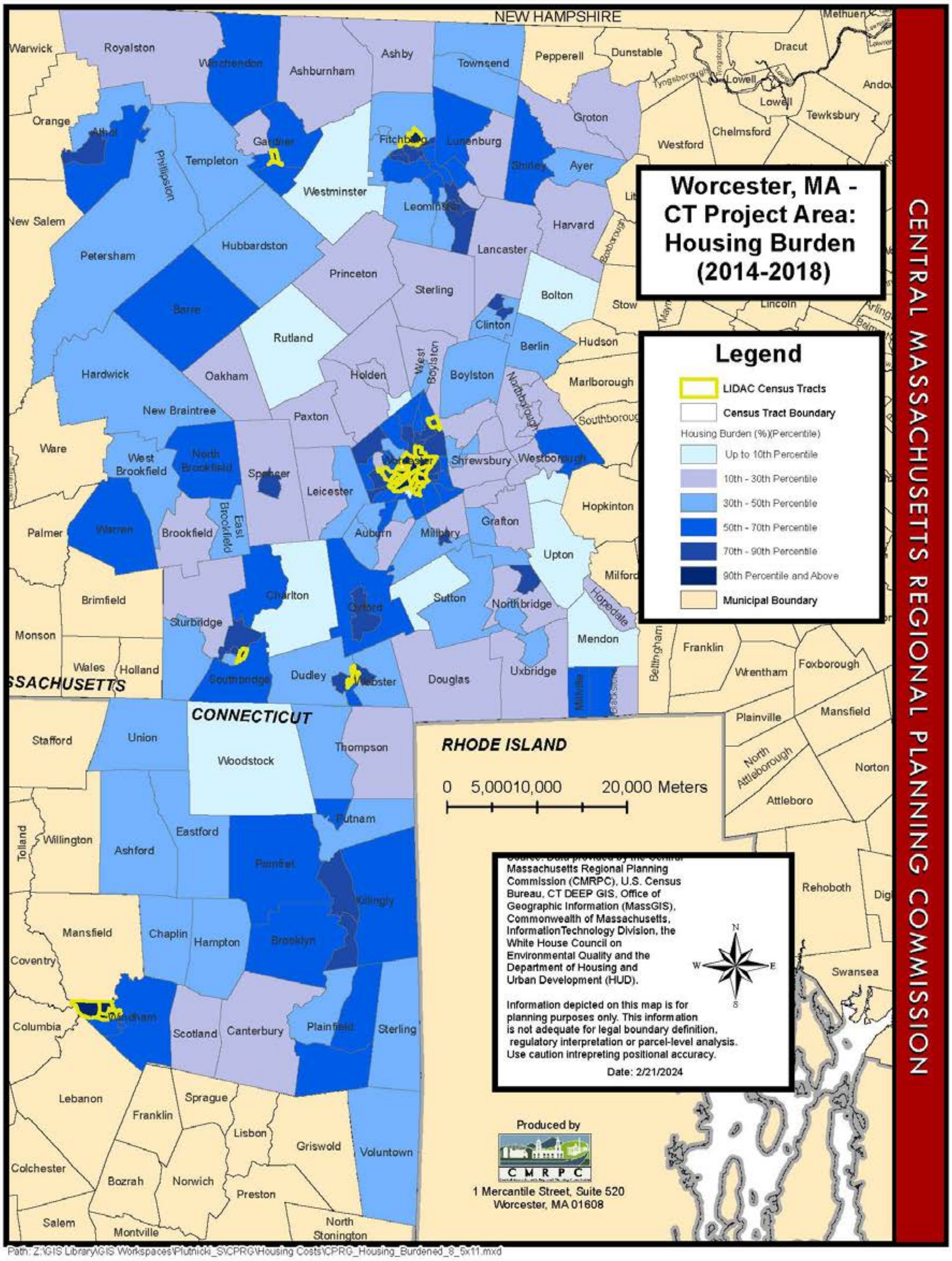
This map depicts the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region that are burdened by energy cost. A LICAC Census Tract is designated as burdened by energy cost if it meets the 90th percentile threshold, meaning it is within the top 10% most burdened areas by the energy cost factor. Specifically, the energy cost factor associated with a specific Census Tract is calculated by dividing the area's average annual energy cost by household income.

This map was created by using the “EBF_PFS” attribute data, or “energy burden (percentile)” from the CJEST shapefile and the “EB_ET” attribute data or the “greater than or equal to the 90th percentile for the energy burden” for the LIDAC analysis. Please note that this map does not depict non-LIDACs that are burdened by energy cost. [ci]



The map on the previous page depicts the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region that are burdened by asthma. A LIDAC Census Tract is designated as burdened by asthma if it meets the 90th percentile threshold, meaning it is within the top 10% most burdened areas by the asthma factor. Specifically, the asthma factor associated with a specific Census Tract is determined by the number of people who have reported being diagnosed with asthma, or the local asthma rate.

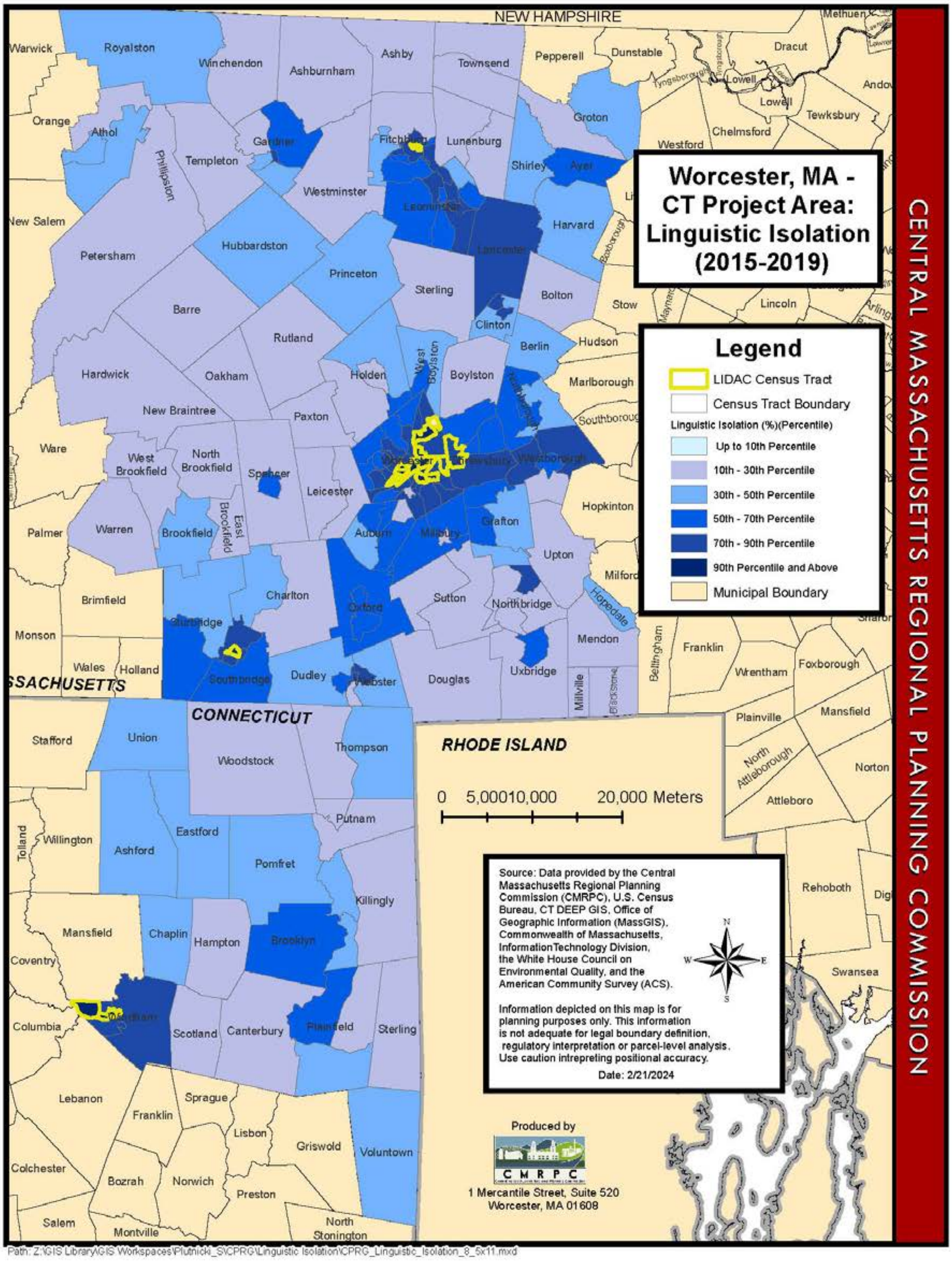
This map was created by using the "AF_PFS" column, or "current asthma among adults aged greater than or equal to 18 years (percentile)" from the CJEST shapefile. Please note that this map does not depict non-LIDACs that are burdened by asthma.[cii]



Path: Z:\GIS Library\GIS Workspaces\Plutnicki_S\CPRG\Housing Costs\CPRG_Housing_Burdened_8_5x11.mxd

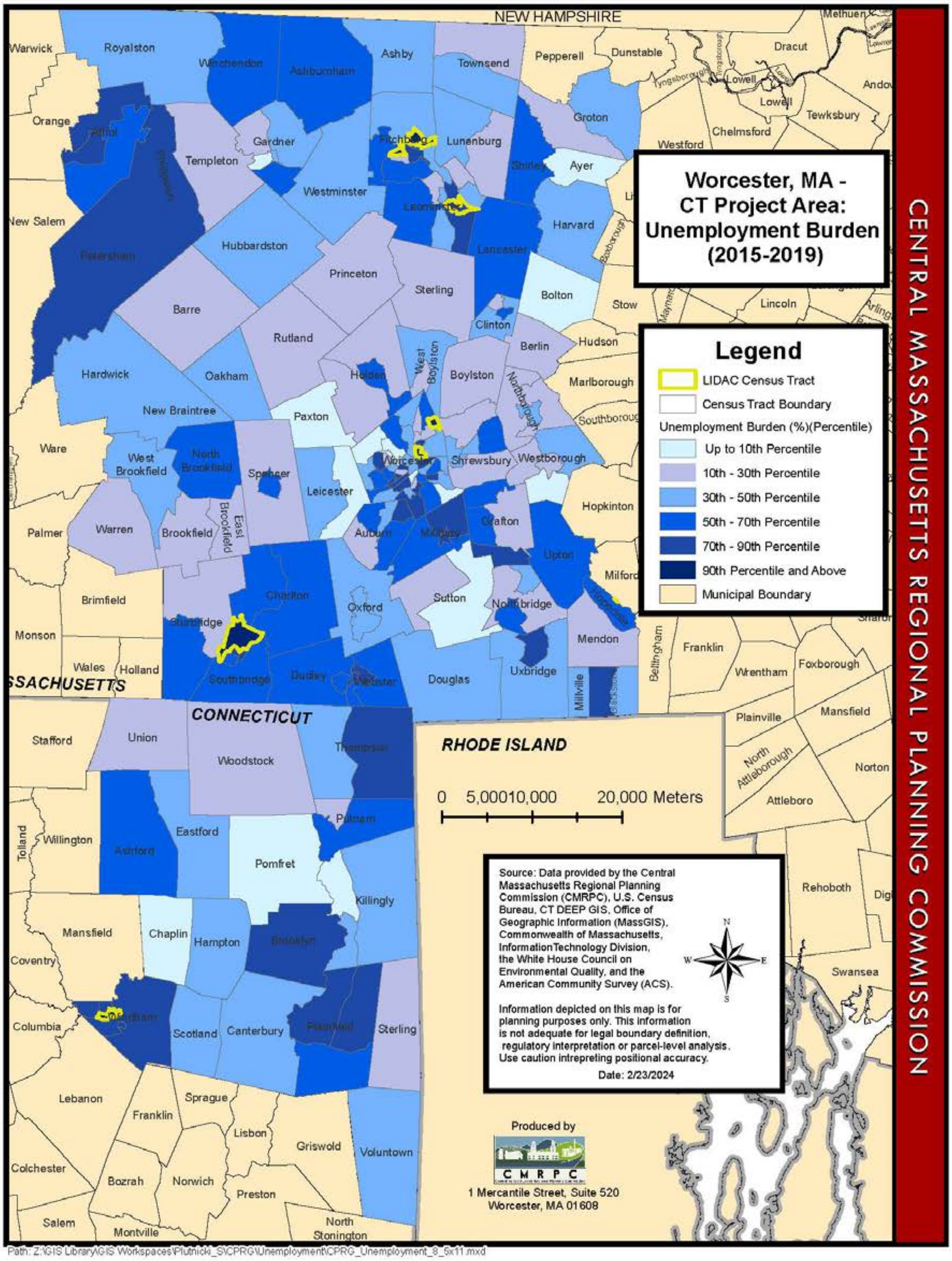
The map on the previous page shows the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region burdened by any specific factors associated with the housing category. This means the LIDACs shown in the following map are burdened by one or more of the following factors: historic underinvestment, housing cost, lack of green space, lack of indoor plumbing, or lead paint. A LIDAC Census Tract is identified as burdened by any of these factors if it meets the 90th percentile threshold for any of these factors, meaning it is within the top 10% most burdened areas by any of the housing factors.

This map was created using the "HBF_PFS" column, or the "housing burden (%) (percentile)" from the CJEST shapefile and the "HB_ET" attribute data, or "greater than or equal to the 90th percentile for housing burden," for the LIDAC analysis. Please note that this map does not depict non-LIDACs that are burdened by any of the factors within the housing category.[ciii]



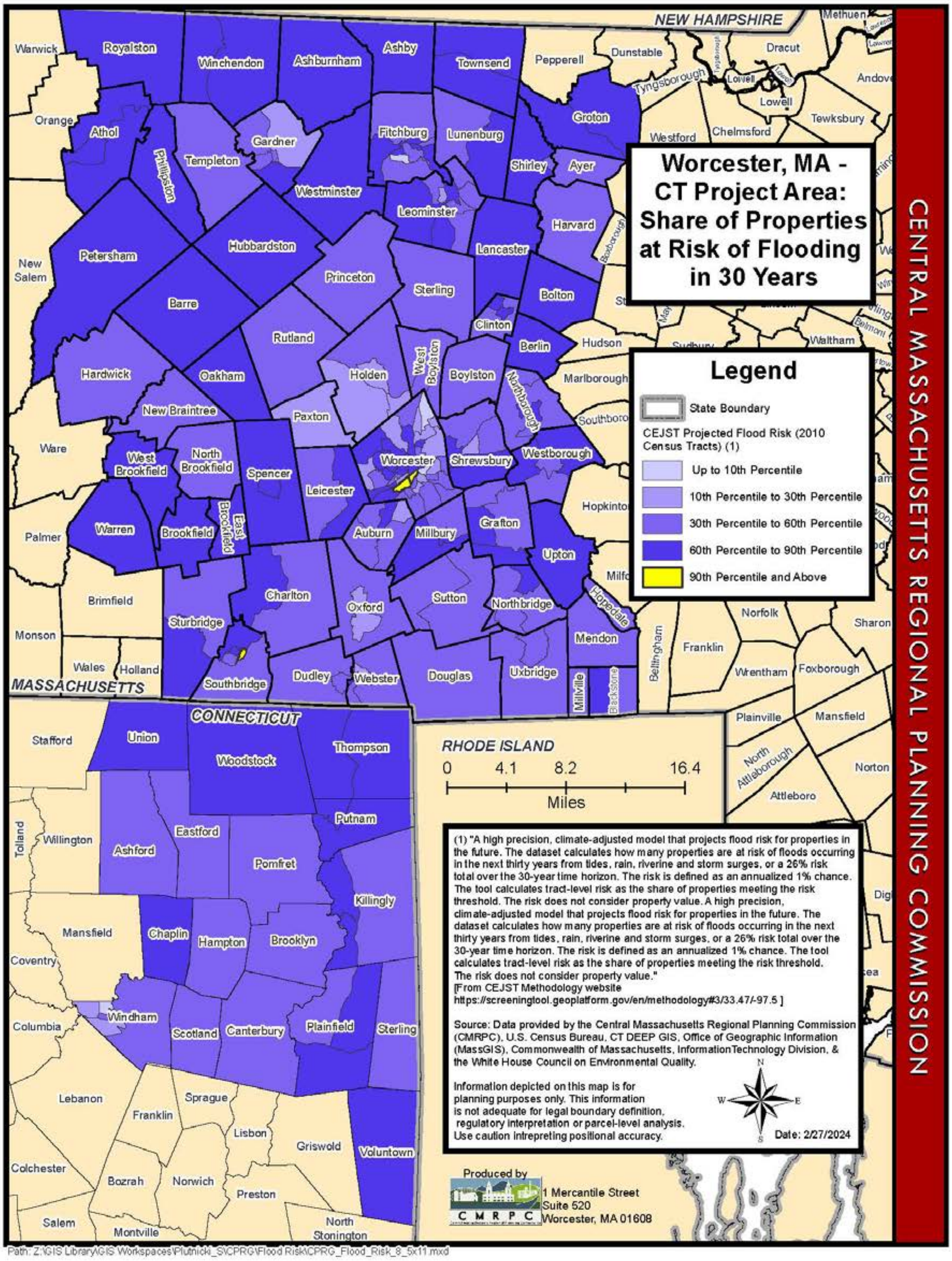
This map depicts the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region that are burdened by linguistic isolation. Linguistic isolation is defined as the share of households where no one over the age of age 14 speaks English very well. A LIDAC Census Tract is identified as burdened by linguistic isolation that meets or exceeds the 90th percentile for households experiencing linguistic isolation.

This map was created using "LIF_PFS" attribute data, or the "linguistic isolation (%) (percentile) from the CEJST shapefile and the "LISO_ET" attribute data, or "greater than or equal to the 90th percentile for linguistic isolation" data, for the LIDAC analysis.[civ]



This map depicts the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region that are burdened by unemployment. A LICAC Census Tract is designated as burdened by unemployment if it meets the 90th percentile threshold, meaning it is within the top 10% most burdened areas by the unemployment factor. Specifically, the unemployment factor associated with a specific Census Tract is determined by the number of unemployed people that participate in the local labor force.

This map was created using “UF_PFS” attribute data, or “unemployment (%) (percentile)” from the CJEST shapefile and the “ULHSE” or the “greater than or equal to 90th percentile for unemployment AND has low HS attainment” for the LIDAC analysis. This means that the LIDACs depicted in this map may be designated as disadvantaged due to the workforce development category. However, the LIDACs depicted in this map may also meet the criteria for being designated as disadvantaged based off other categories of burdens. Please note that this map does not depict non-LIDACs that are burdened by unemployment.[cv]



Finally, this map depicts the LIDAC Census Tracts within the Greater Worcester Climate Pollution Reduction Grant (CPRG) Region that are burdened by an increased risk of flooding. This dataset calculates the number of properties that are at risk of floods occurring in the next thirty years from tides, rain, riverine and storm surges, or a 26% risk over 30 years. Tract-level risk is calculated as the share of properties that meet this risk threshold. Property values are not included in this analysis.

This map was created using the "FLD_PFS" attribute data or "share of properties at risk of flood in 30 years (percentile) from the CEJST shapefile data. LIDACs were chosen using the "FLD_ET" attribute data, or Census Tracts with flooding burden that meet or exceeds the 90th percentile for share of properties at risk of flooding in 30 years. Please note that this map does not depict non-LIDACs that are burdened by flooding risk. [cvi]

Greater Worcester Priority Climate Action Plan

The Greater Worcester Priority Climate Action Plan

Purpose

This plan reduces climate pollution in the Worcester MA-CT Metro area by decreasing anthropogenic greenhouse gas and air pollution emissions. This plan aims to accomplish its purpose by reducing combustion of fossil fuels, minimizing waste across multiple sectors, and preserving natural carbon sinks in the region.

Emissions Inventory

To understand the Worcester, MA – CT MSA's emissions, a greenhouse gas (GHG) emissions inventory was conducted. This inventory estimates the carbon dioxide, methane, and nitrous oxide emissions from a wide array of emitting sources, using publicly available datasets and standardized equations. While these gases already naturally exist in the environment, the burning of fossil fuels for human activities (such as driving a car or heating a building) is accelerating the rate at which these GHGs are being emitted. This, in turn, is causing the rate at which heat is being trapped in the Earth's atmosphere to increase, leading to long-term shifts in temperature and climate.

A baseline GHG inventory is therefore a necessary first step in understanding the quantity of emissions output by the MSA. From this baseline, emissions reductions measures and net-zero goals can be quantified and compared. For this GHG emissions inventory, 2017 was selected as the baseline year. 2017 is a recent year to track progress yet remains independent of COVID-19 emissions effects. For relevant Connecticut cities and towns, similar methodology was applied, using more appropriate publicly available federal and state datasets. To assess progress toward reducing emissions, this baseline inventory can now be updated and used for comparative purposes.

GHG emissions are typically quantified in units of metric tons of carbon dioxide equivalent ($MTCO_2e$) or millions of $MTCO_2e$ ($MMTCO_2e$). Global warming potentials for methane and nitrous oxide are then used to normalize these greenhouse gases to CO_2. The following equation is generally used to calculate emissions:

Activity Data (e.g., kWh, gallons) X **Emissions Factors** (e.g., MTCO2e/kWh, $MTCO_2e$/gallon) = **Emissions ($MTCO_2e$)**

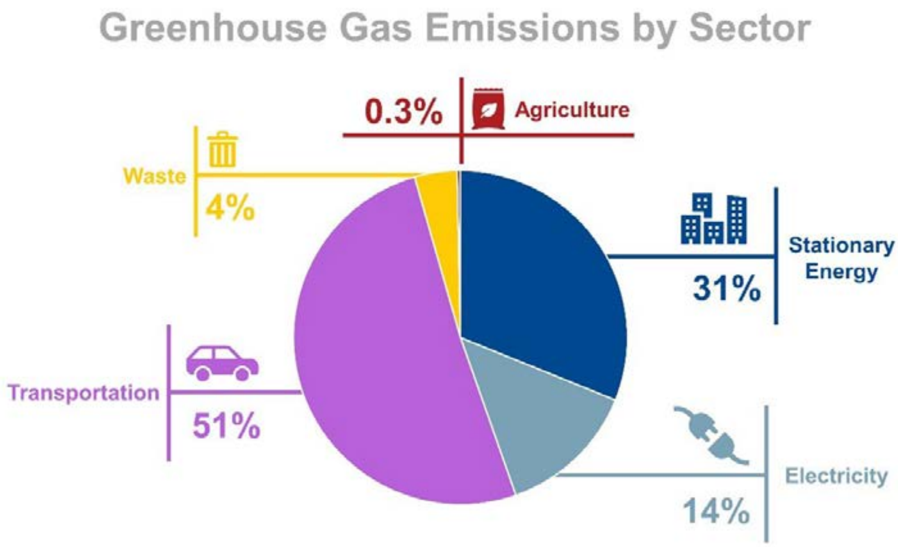
9.1 $MMTCO_2e$

were emitted in 2017 by the MSA, including

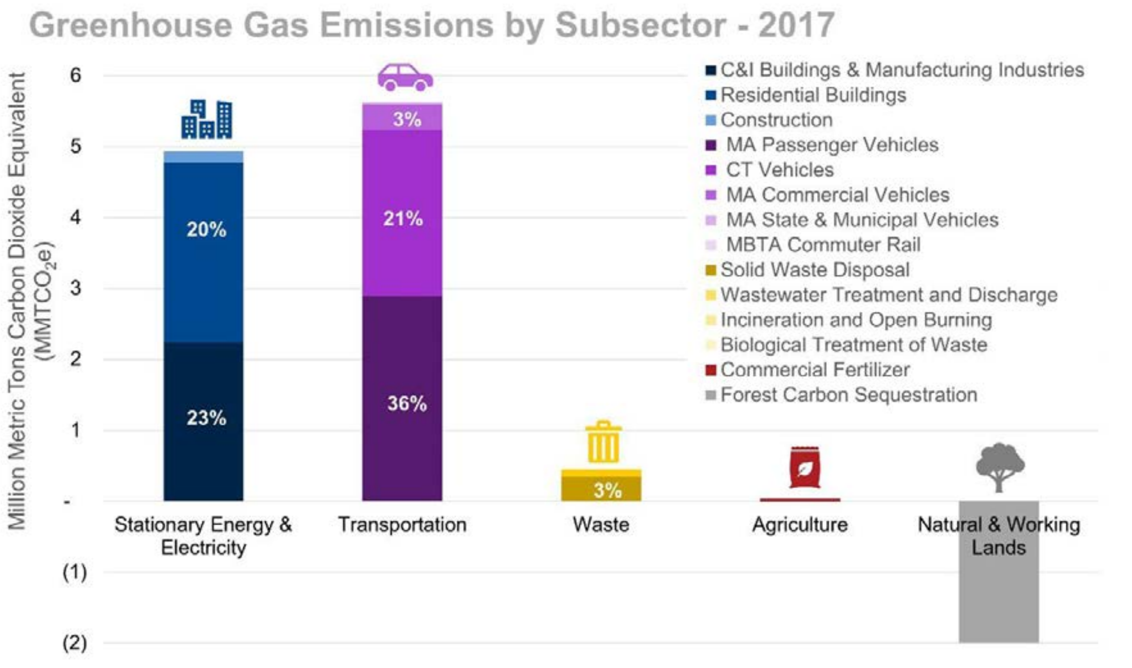
This PCAP GHG emissions inventory includes a comprehensive set of emissions sources, across six unique sectors. The sector of emissions sources, key data that informed emissions calculations, and the result of those calculations can be found in Table 8.

Table 8: GHG Emissions Inventory Sectors, Key Data, and Resulting Emissions

Sector	Key Data	Emissions (MMT CO2e)
Stationary Energy	Residential and commercial/institutional usage (natural gas, fuel oil), off-road equipment	3.4
Electricity	Residential & commercial/institutional usage, transmission and distribution losses (investor-owned utilities, municipal utilities, and community aggregation)	1.5
Transportation	Passenger vehicles, commercial vehicles, MBTA (Massachusetts Bay Transit Authority) commuter rail	5.6
Waste	Landfilled and incinerated waste, composted and anaerobically digested waste, wastewater	0.5
Agriculture	Commercial fertilizer usage	0.03
Natural & Working Lands	Tree carbon sequestration based on canopy	-2.0
	Total Net Emissions (MMT CO_2e)	**9.1**



The three largest emitting sectors in the MSA include transportation, stationary energy, and electricity, with the four largest subsectors consisting of MA passenger vehicles, all CT vehicles, commercial & industrial buildings and manufacturing industries, and residential buildings.



The full inventory can be found in Appendix A. Additional information about data sources and methodology can be found in Appendix B. Co-pollutant information can be found in Appendix C.

Public Engagement

Overview

CMRPC staff members collaborated with staff from MRPC (the Montachusett Regional Planning Commission) and NECCOG (the Northeastern Connecticut Council of Governments) to plan and facilitate a robust series of free public workshops throughout the Greater Worcester Region as part of the Climate Pollution Reduction Grant process. The goals of these workshops were to receive public feedback on what priority short-term, implementable, effective climate pollution reduction actions are favored in the region and, secondarily, to inform the public about the Climate Pollution Reduction Grant program.

Regional Planning Agency staff members emphasized environmental justice considerations and the importance of prioritizing projects that benefit LIDACs (low income and disadvantaged communities) and EJ communities throughout the planning and facilitation of these workshops. All six of the climate polluting sectors identified by the EPA (transportation, waste management, commercial and residential buildings, agricultural, natural, and working lands, electricity, and industry) were discussed at each of these workshops. Workshop attendees were asked to be ambitious and imaginative in brainstorming ideas for how they would like to see federal CPRG implementation grant dollars spent to the benefit of their communities and the Greater Worcester region. They were also asked to focus on solutions that would benefit their communities and the region regardless of what their political beliefs or views on climate change were.

Ten GWPCAP public engagement workshops were held in the Greater Worcester region between November 2022 and February 2023. CMRPC staff completed six workshops in the six sub-regions of the CMRPC region between November 2023 and January 2024. Following these six workshops, NECCOG hosted three workshops within their planning region and MRPC hosted one hybrid workshop for their entire planning region.

Table 9: List of Public Engagement Workshops

Region	Location	Date	Time	Modality
CMRPC West	West Brookfield Town Hall, West Brookfield, MA	November 15th, 2023	6pm-9pm	In-person
CMRPC Northeast	Shrewsbury Public Library, Shrewsbury, MA	November 30th, 2023	6pm-8:30pm	In-person
CMRPC Southwest	Gladys E. Kelly Public Library, Webster, MA	December 7th, 2023	6pm-8:30pm	In-person

CMRPC North	Quabbin Regional Middle High School, Barre, MA	December 18th, 2023	6pm-8pm	In-person
CMRPC Southeast	Northbridge Town Hall, Northbridge, MA	January 10th, 2024	6pm-8pm	In-person
CMRPC Central	Worcester Polytechnic Institute Campus Center, Worcester, MA	January 18th, 2023	6pm-9pm	Hybrid
NECCOG	Thompson Library and Community Center, Thompson, CT	January 29th, 2023	6pm-7:30pm	In-person
NECCOG	Plainfield Town Hall, Plainfield, CT	January 30th, 2023	6pm-7:30pm	In-person
NECCOG	Windham Town Hall, Windham, CT	January 31st, 2023	6pm-7:30pm	In-person
MRPC	Montachusett Regional Planning Commission Office, Leominster, MA	February 16th, 2024	6:30pm-9pm	Hybrid

Using the ideas of workshop attendees as a valuable resource alongside relevant ideas from already existing local and regional plans, CMRPC staff drafted a list of 20 priority climate pollution reduction actions. These actions span five out of the six climate polluting sectors (industry was not identified as a major priority sector in the region by workshop participants). CMRPC then published a survey in which residents and stakeholders could rank each action as very high priority, high priority, neither high nor low priority, low priority, or very low priority. This survey was E-mailed to workshop attendees and promoted on CMRPC's social media pages. It was open from February 9th through February 26th, 2024.

Workshop Outreach

Regional Planning Agency staff prioritized siting workshops in LIDACs (low income and disadvantaged communities), with the highest priority given to federally designated Justice40 LIDACs and the second highest priority given to Massachusetts and Connecticut designated environmental justice communities. Workshops were held in four (Leominster, Webster, Windham, and Worcester) out of the seven municipalities which have federally designated low-income and disadvantaged Census Tracts in the Greater Worcester region.[cvii] Eight out of the ten workshops were held in municipalities with Massachusetts or Connecticut designated environmental justice Census block groups.[cviii]

CMRPC staff completed extensive flyering efforts before each of the six workshops within the CMRPC region, posting flyers for the workshops at public spaces within every municipality in the region, including all three municipalities with Justice40 LIDACs. Thes types of locations these flyers were posted at include town halls, libraries, community centers, convenience stores, pizza shops, post offices, senior centers, schools, and more. CMRPC staff also conducted extensive outreach for the workshops through E-mail blasts and social media flyers.

Both the NECCOG and MRPC workshops were promoted using a flyer like the CMRPC's promotional flyer. These promotional flyers were shared with NECCOG and MRPC region residents and stakeholders through email blasts, social media, and the organizations' websites. Both NECCOG and MRPC created and shared registration links for the workshops they hosted. Flyers for the MRPC workshop were translated from English into French, Haitian Creole, Portuguese (Brazilian), and Spanish. The MRPC workshop flyers also asked people to register in advance of the workshop and to indicate if they would need or want translated materials.[cix] Please visit https://www.mrpc.org/comprehensive-planning/climate-pollution-reduction-strategies to read more about MRPC's efforts for the CMRPC's CPRG planning process.

GWPCAP Website

CMRPC developed a website for the Greater Worcester CPRG planning efforts. This website includes information about the grant program, CMRPC's planning efforts and progress as a lead entity, and a calendar of events. This calendar was regularly updated throughout the public workshop series. CMRPC embedded a direct link to this website and the calendar onto a QR code for all the promotional workshop flyers in the CMRPC planning region. Workshop attendees were also offered a flyer including information about how to stay in touch with the Greater Worcester CPRG process. CMRPC will continue to update this website throughout all three phases of the CPRG process. To visit this website, please visit https://www.cmrpc-cprg.com/.

Workshop Structure

The public engagement workshops had a similar structure overall, but some aspects of the workshops were altered to accommodate different subregions and various levels of attendance.

The general workshop structure was threefold.

- First, RPA staff presented a 15-minute slideshow going over the Climate Pollution Reduction Grant program and timeline, the greenhouse effect and the difference between air pollution and climate pollution, the broad-level impacts of climate change, environmental justice considerations, the six climate polluting sectors, and the workshop logistics and activities.

- Next, workshop attendees participated in discussions facilitated by RPA staff brainstorming priority climate pollution reduction actions they want implemented in their communities.
- Finally, attendees participated in voting activities. In the first activity, they ranked draft goals for the GWPCAP in each climate polluting sector by their priority / importance; they were also able to propose a goal of their own in this activity. In the second activity, they were given two “tickets” which they could “invest” in the sector or sectors that they would like to see prioritized for the GWPCAP. During this time, attendees could also look at posters and maps with information on each one of the climate polluting sectors as well as packets with subregion-specific data and state and federal funding sources for each of the sectors. They could also converse with each other and RPA staff.

Food and kids' activities were provided at each of the in-person workshops. Anonymous comment boxes where attendees could share any concerns or ideas that they were not comfortable sharing aloud were present at each of the workshops.

Summary of Feedback Received

The four main categories of public feedback received within the public engagement process were:

- The prioritization of climate polluting sectors
- The prioritization of draft GWPCAP goals and proposed additional/alternate goals.
- Feedback from the large group discussions at the workshops and the smaller-group and one-on-one discussions from the third part of the workshops.
- The results of the draft climate pollution reduction actions survey

The following table shows the results of the sector prioritization activity in which workshop attendees were given two “tickets” each to “invest” in one or two sectors.

Sector	Number of Tickets
Transportation	78
Electricity	43
Waste Management	43
Agricultural, Natural, and Working Lands	29
Commercial and Residential Buildings	26
Industry	11

The results of this activity show that workshop attendees' highest priority sector for climate pollution reduction investment, by a large margin, was transportation. Electricity and waste management were also highly prioritized by attendees, while agricultural, natural, and working lands and commercial and residential buildings were moderately prioritized. According to this activity, industry was the lowest-priority sector for workshop attendees.

Several major cross-cutting themes across sectors were brought up repeatedly by workshop attendees and informed the content of this GWPCAP.

- The importance of providing ongoing education to all people, regardless of their age, background, or geography, regarding air and climate pollution as well as strategies to address them that provide co-benefits to diverse communities.
- The importance of reaching consensus on air and climate pollution reduction actions and working bottom-up to address the address the unique needs of different communities.
- The importance of understanding that air and climate pollution are systemic, large-scale problems which require systemic and large-scale, not just personal and locally driven, solutions.

Following the GWPCAP public outreach efforts, CMRPC conducted a robust analysis of all the quantitative public feedback collected to determine overall priorities. The following table illustrates the analysis used to determine the "urgency" related to each of the four draft goals under the six major climate polluting sectors. Using results from the overall sector investments activity and goal ranking activity, each goal received a ranking of either "not as important", "important", "very import", or "critical".

Table 10: Goal Prioritization

Goal	Urgency	Goal	Urgency
Agricultural, Natural & Working Lands		**Industry**	
A.1. Reduce/disincentivize land clearing and permanently protect land and water	Important	I.1. Upgrade industrial facilities using energy efficient industrial technologies	Not As Important
A.2. Increase carbon sequestration capacity	Important	I.2. Change industry regulations/promote programs to produce goods from recycled, recyclable, or renewable materials rather than raw materials	Important

A.3.	Scale up sustainable land use practices	Important	I.3.	Raise awareness about and increase training for the prevention of emission leaks from industrial equipment	Not As Important
A.4.	Improve livestock and manure management	Not As Important	I.4.	Scale up fuel switching efforts that result in less CO2 emissions	Not As Important
	Residential & Commercial Buildings			**Transportation**	
B.1.	Reduce energy use in residential, commercial, and municipal buildings via enhanced energy efficiency measures (i.e., weatherization measures, air conditioning, and refrigeration equipment)	Important	T.1.	Reduce overall vehicle travel demand and improve mobility for all modes of transportation (i.e., active transportation and transit)	Critical
B.2.	Power residential, commercial, and municipal buildings with exclusively electricity (i.e., electric heat pumps, electric water heaters)	Important	T.2.	Improve the operational efficiency of freight and fleet	Critical
B.3.	Promote passive heating and cooling measures through building design	Not As Important	T.3.	Improve fuel efficiency	Critical
B.4.	Improve energy efficiency of drinking water, wastewater, and waste management buildings	Not As Important	T.4.	Electrify personal transportation networks and scale up fuel switching efforts	Critical
	Electricity			**Waste Management**	
E.1.	Scale up fuel switching efforts that result in less CO2 emissions (i.e., renewables and nuclear)	Critical	W.1.	Reduce contamination in/improve the quality of residential recycling streams	Very Important
E.2.	Increase the efficiency of and/or decommission existing fossil fuel-fired power plants	Very Important	W.2.	Sustainably manage disposal facilities within the MSA (i.e., landfills, waste incineration facilities, etc.)	Very Important
E.3.	Reduce overall electricity use and peak demand	Very Important	W.3.	Phase out difficult to recycle materials	Very Important

E.4.	Scale up energy transmission infrastructure/grid connections	Very Important	W.4.	Reduce the amount of waste being disposed	Critical

Strategies to Mitigate Climate Pollution by Sector

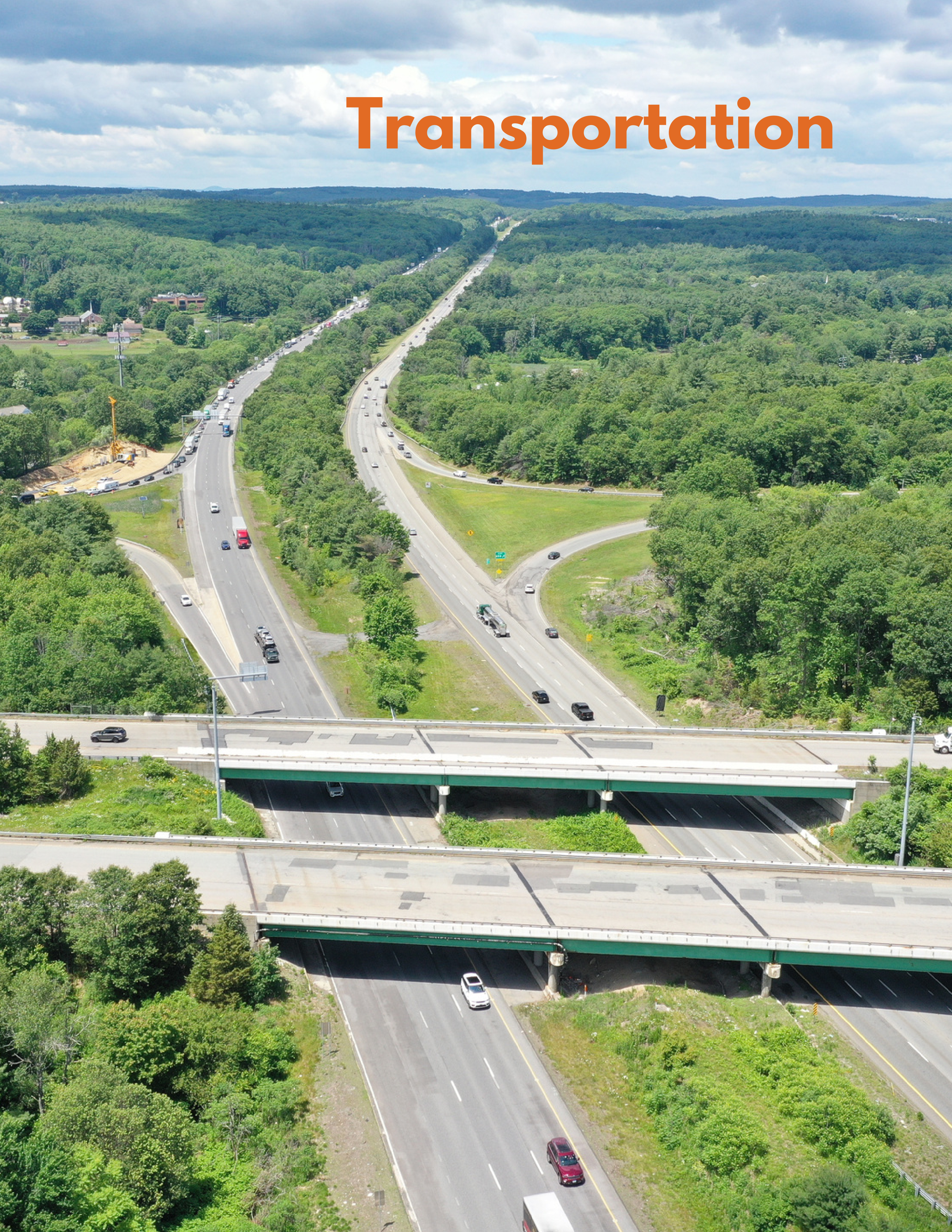
Following the analysis of sector investments and goals, CMRPC conducted a comprehensive analysis of the draft pollution reduction measures using the quantitative feedback from the priority actions public survey and the GHG reduction calculations associated with each action provided by Weston & Sampson. The results of the analysis of sector investments and goals were woven into this final comprehensive analysis. The following table illustrates each draft action's overall "priority" on a scale from "low" to "high". Please note that in this plan, there is no Industry sector section. While we acknowledge the importance of reducing emissions in the industry sector, all four goals for Industry ranked very low for a priority. The sector will be looked at in close detail in the Comprehensive Climate Action Plan.

Table 11: Priority Strategies

Sector	Strategy	Emission Reduction per year (MT CO_2e)	Priority
W	Create local/regional composting programs and establish a Regional Waste Management Entity to oversee the implementation of organics and waste diversion programs across the MSA.	47,411	High
B	Create an accessible online tool to connect residents with free, comprehensive consultation for how to make their homes energy efficient. This program's goal will be to provide weatherization retrofits for 50% of the MSA's housing stock 2035. Priority will be given to older buildings, particularly homes built before standard building codes were enacted.	143,449	High
T	Expand fare-free public transit service	1,178	High
E	Provide incentives to establish solar array over 15 individual Brownfields, Capped Landfills, and/or Closed Fuel Facilities by 2035	20,601	High
E	Establish a rooftop solar array for 25 municipal, public hospital, and/or public-school building rooftops by 2035.	9,082	High

E	Institute a solar canopy system on 40 municipal and/or school parking lots by 2035.	9,525	Med
W	Create new anaerobic digester infrastructure and foster local partnerships to guarantee a steady supply of organics, especially partnerships with LIDACs/stakeholders with connections to LIDACs.	17,228	Med
W	Restrict use of plastic bags, straws, bottles, takeout containers, and detergent containers across the MSA.	25,478	Med
A	Establish an urban tree and shrub planting program	2,708	Med
E	Provide 15 communities with one battery storage system each.	627	Med
T	Electrify regional public transit buses and install associated charging infrastructure	355	Med
T	Implement 30 miles of protected bike lanes and shared-use paths in EJ communities	299	Med
B	Replace existing inefficient building heat systems with electric heat pumps in 50% of municipal and/or school buildings by 2035.	35,824	Med
B	Provide weatherization retrofits in municipal and school buildings, particularly through replacing 75% of inefficient municipal and/or school windows by 2035.	4,846	Med
A	Permanently protect forestland in MA and CT	235	Med
T	Purchase 10 Electric or hybrid vehicles to expand ridesharing/shuttle service with priority given to communities without access to regional transit and EJ communities	427	Low
T	Implement bike-sharing in EJ communities	311	Low
A	Assist young farmers to purchase local land for food production	0	Low
T	Electrify senior vans in EJ communities	206	Low
A	Create a green roof rebate program	40	Low

Transportation



Transportation

Getting from one place to another in an accessible, convenient, and safe way is crucial to the livelihoods of most people in the modern world. Whether it is used to get to school, work, recreation, or errands downtown, transportation gets people to places where they need to be to connect with other people and help society run smoothly. Currently, by far the most common way to traverse all but the shortest distances in the USA as well as the Greater Worcester region is by personal automobile. Fossil fuels also power most people's trips in the country and region. This combination of a personal automobile centric culture and the predominance of fossil fuel power for transportation has led to elevated levels of greenhouse gas emissions from the transportation sector in both the country and the region.

This GWPCAP provides strategies that aim to reduce emissions from the transportation sector in the Greater Worcester region in the upcoming decade. Stakeholders throughout the region have great interest in reducing car dependency and enhancing public transportation, cycling, rolling, and pedestrian infrastructure in the region. An increase in the use of non-automatic forms of transportation will reduce greenhouse gas emissions. This change will also provide quality of life benefits to all of society and especially to low-income and disadvantaged communities. Therefore, the strategies developed for this plan focus on transit and active transportation.

However, regional stakeholders also acknowledge that personal (or shared) automobile use will still be the most efficient way to make connections between many important destinations in rural areas even if significant improvements are made to the region's transit and active transportation systems. Also, due to how greatly entrenched car centric infrastructure is in the region, it will take time for active transportation and transit improvements to multiply and lead to significant greenhouse gas emissions reductions. Therefore, electrification of personal vehicles in the region and the powering of this electricity by renewable resources are both crucial for emission reductions in the short term as well as important for such reductions in the long term. Although the strategies in this plan do not focus on personal electric vehicle charging and use, a strategy from the Massachusetts GWPCAP does. The strategy is called "Adopt Zero or Low Emission Light-Duty Vehicles" and has an implementation concept of "Passenger vehicles: Accelerate the adoption of zero tailpipe emission vehicles through rebates, vehicle procurement, and charging infrastructure development" (STRAW - PROPOSAL Massachusetts Priority Climate Action Plan, p. 14)[cx]. Stakeholders in the Greater Worcester Region will aim to use this strategy to reduce personal vehicle greenhouse gas emissions. The next step of this CPRG process is to create a comprehensive climate action plan for the Greater Worcester region, which will discuss personal vehicle electrification in greater detail.

How does the transportation sector contribute to climate pollution?

In the Greater Worcester Region, the transportation sector is the greatest contributor to climate polluting emissions among the six sectors analyzed in this report. According to the greenhouse gas inventory for the region completed by Weston and Sampson, 51% of greenhouse gas emissions in the region from 2017 were from transportation.[cxi] Transportation emissions amounted to 37% of Massachusetts statewide GHG emissions in 2020[cxii] and 40% of Connecticut statewide GHG emissions in 2019.[cxiii] The transportation sector also accounted for 28% of greenhouse gas emissions in the United States in 2021.[cxiv]

Most automobiles currently on the road in the country and the region, including cars, trucks and buses, are powered by internal combustion engines which use oil-based fuels such as gasoline and diesel.[cxv] When these fuels are burned, they produce carbon dioxide, the most common greenhouse gas, other greenhouse gases such as methane and nitrous oxide,[cxvi] and other health-damaging pollutants like smog and carbon monoxide which are released by vehicle tailpipes.[cxvii] Cars, trucks, and buses also emit hydrofluorocarbons (HFCs) from leaking air conditioners; these chemical releases are small in magnitude but are significant because HFCs have a high global warming potential.[cxviii]

Greenhouse gas emissions also result from the production of vehicles and vehicle parts, the production of vehicle fuels, the transportation of vehicles and vehicle parts, the construction of roads, and the recycling and disposal of vehicles and vehicle parts[cxix].

Although they are significantly more efficient than automobile transport, both passenger and freight railroad transportation systems also lead to greenhouse gas emissions. These emissions stem from diesel fuel being used to power railroad vehicles and the construction, maintenance, and disposal of railway infrastructure.[cxx]

It is important to note that the car-centric development patterns which abound in many parts of the country and the region greatly inflate the amount of greenhouse gas emissions from the transportation sector; these land use patterns, including sprawling housing developments, suburban office parks and retail hubs, and Interstate highways which divide cities, often make it very difficult for people to get to important destinations by means other than a personal vehicle. These land use patterns were enthusiastically promoted within the country and the region in the 20th century coupled with substantial disinvestment in public transportation. Personal vehicles emit a higher amount of greenhouse gases per rider than public transportation does.[cxxi]

All these factors lead to greenhouse gas emissions from the transportation sector, and greenhouse gas emissions lead to climate pollution due to the greenhouse effect.

Transportation Emissions Contribution

In the Greater Worcester Region, on-road emissions from gasoline-powered vehicles were by far the most common source of greenhouse gas emissions from the transportation sector in 2017, according to the greenhouse gas inventory completed by Weston and Sampson; these on-road gasoline emissions accounted for 46% of total emissions across all sectors in this analysis. On-road diesel emissions were the second most common source of emissions in this sector, and they accounted for 5% of emissions across all sectors of the inventory. Railroad diesel emissions were the next most common source of emissions in the transportation sector for the region according to this analysis; they were followed by, respectively, on-road electricity emissions and transmission and distribution losses of electricity which powers on-road vehicles. None of these three emissions sources accounted for more than 1% of emissions across all sectors of the analysis.

Table 12: GHG Emissions from Transportation by Subsector and Source, Worcester, MA-CT MSA (2017)

Sector	Subsector	Source	Carbon Dioxide Equivalent Emissions (MT CO2e)
Transportation	On Road	Diesel	557,715.46
		Electricity	1,322.11
		Electricity T&D Losses	67.72
		Gasoline	5,057,806.14
	Rail	Diesel	10,869.33

Data Source: Worcester, MA-CT Metropolitan Statistical Area Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cxxii]

Weston and Sampson were able to calculate a breakdown of on-road emissions from different types of vehicles for the areas of the region within Massachusetts. Passenger vehicles in Massachusetts led to the greatest amount of on-road emissions among the different vehicle types in 2017 according to this analysis; they led to 26.2% of emissions across all sectors and the region as a whole, as compared to 3.3% for commercial vehicles in the state and 0.2% for state and municipal vehicles in Massachusetts.

Table 13: GHG Emissions from Transportation

by Vehicle Type, Worcester, MA-CT MSA (2017)

Subsector	Vehicle Type	Gasoline Fuel Consumption (gal)	Diesel Fuel Consumption (gal)	Electricity Consumption (kWh)	Electricity T&D Losses (kWh)	CO2e Emissions (MT CO2e)
On Road	MA Passenger Vehicles	322,473,358.1	2,808,981.56	4826875.03	247,619	2,890,303
	MA Commercial Vehicles	27,673,469.69	11,049,442.11	18,745.20	962	359,433
	MA State and Municipal Vehicles	2,026,520.97	472,166.7	8,261.28	424	22,846
	CT Vehicles	218,091,483	39,732,172	562,202.84	28,841	2,344,328
Rail	MBTA Commuter Rail	N/A	1,053,630.67	N/A	N/A	10,869

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cxxiii]

These figures highlight the joint importance of electrifying the region's vehicle fleet, providing this electricity from renewable sources, and incentivizing mode-shift from personal vehicles to public transportation, walking, rolling, and cycling for the green energy transition for the transportation sector.

Regional Context

Massachusetts

The Massachusetts Department of Transportation (MassDOT) recognizes that climate change will significantly impact life in the Commonwealth. For example, MassDOT acknowledges that extreme precipitation, high winds, and recurring flooding will overwhelm and degrade transportation infrastructure throughout the state. For these reasons, climate change considerations are a major component of their long-range transportation plan (LRTP) planning process. The purpose of the MassDOT LRTP, *Beyond Mobility*, is to guide transportation decision-making and investments to maximize equity and resilience while advancing the Commonwealth's goals. In addition to supporting clean transportation and infrastructural resiliency, the LRPT will consider safety, reliability, connectivity, and travel experience for all major modes of transportation. [cxxiv]

The City of Worcester's recently (July 2022) established Department of Transportation and Mobility (DTM) is also developing a transportation plan.[cxxv] Specifically, the Worcester DTM is developing a Mobility Action Plan (MAP) that will illustrate pathways towards safe, sustainable, and equitable transportation networks for people of all ages and abilities. The Worcester DTM recognizes that to provide safe and equitable transportation networks for all people, infrastructure must support all modes of mobility other than just driving alone in a personal vehicle.[cxxvi]

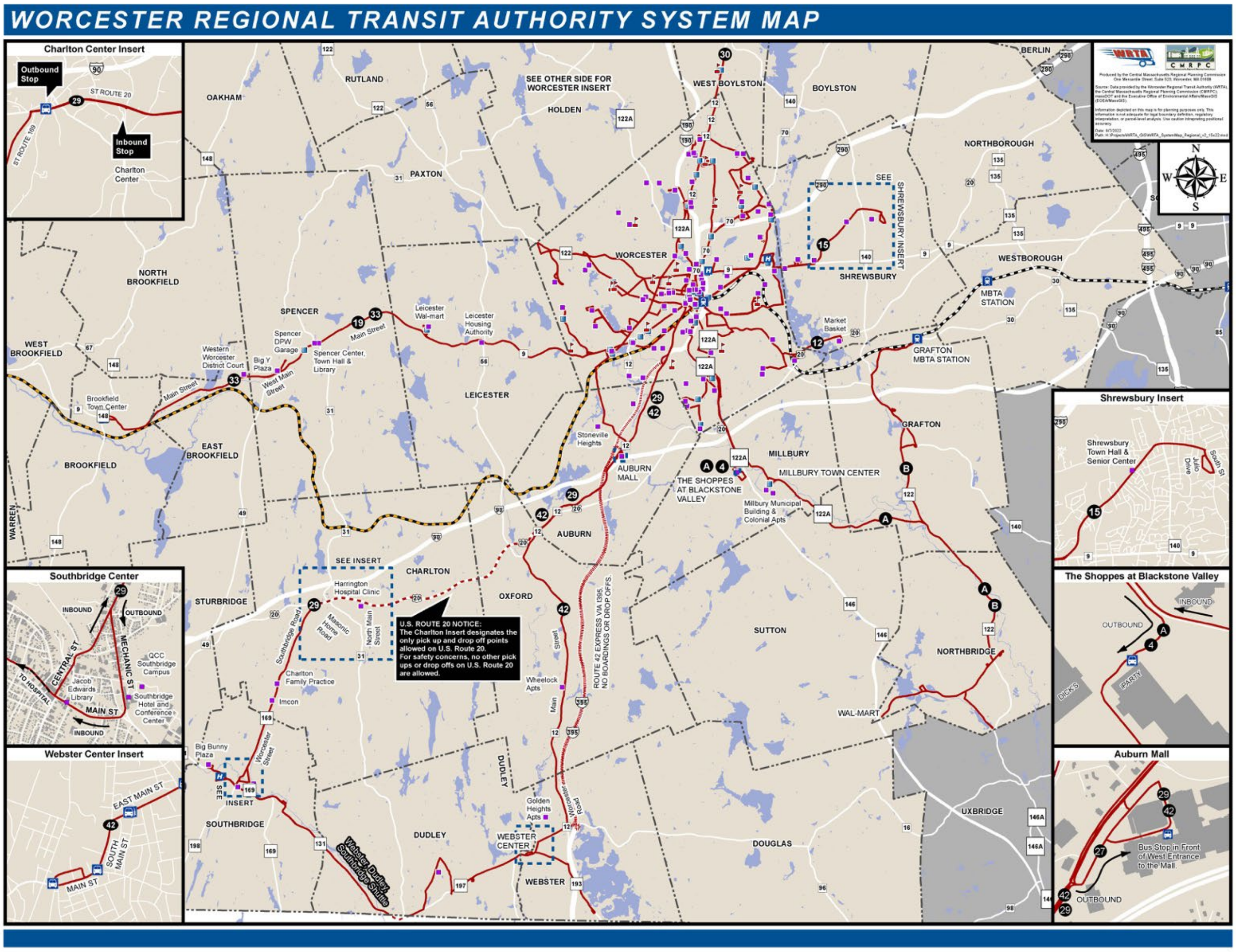
Connecticut

Sustainability and climate resilience are major considerations in the Connecticut Department of Transportation's (CTDOT) 2018 to 2050 long range transportation plan (LRTP). Specifically, the CTDOT LRTP encompasses four goals related to livability and resilience: livable, healthy, and environmentally sustainable communities; enhanced bicycling and walking accommodations and opportunities; environmentally friendly transportation that is affordable; resilient transportation systems. Various objectives were developed to guide the state towards these goals, including integrating the CTDOT's Complete Streets policies into design and programming and reducing energy and resource use wherever possible. [cxxvii]

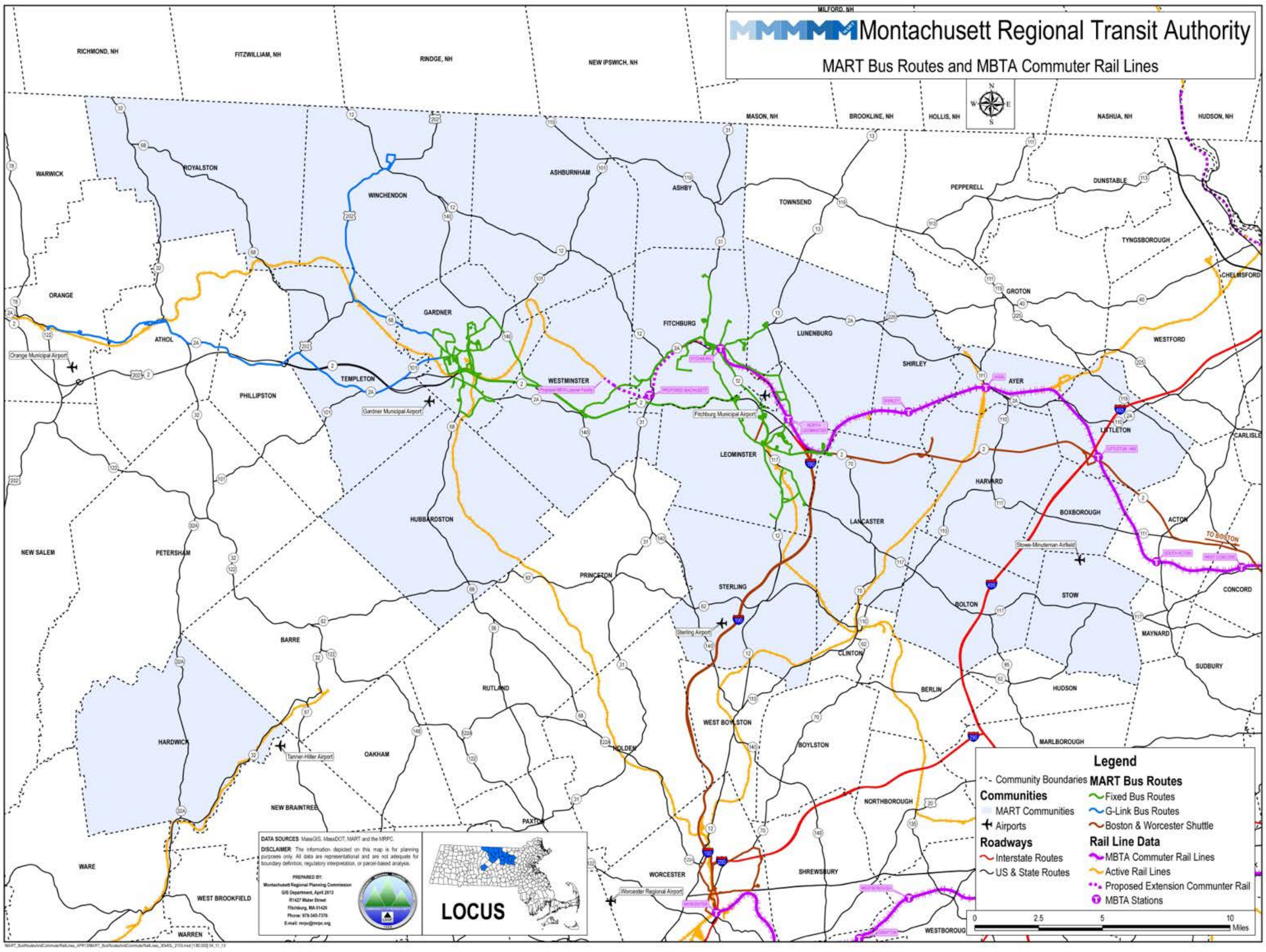
Greater Worcester Region

The Greater Worcester region's transportation sector was responsible for 51% of total emissions during 2017.[cxxviii] Nonetheless, the Greater Worcester region is clearly committed to increasing equitable access to sustainable and resilient mobility options and transportation infrastructure. The need for this commitment is not only evidenced in the emissions contribution of the region's transportation sector, but also the inequities of the region's existing transportation systems, which are car-centric and income- and ability-dependent. As the region works to reduce the GHG emissions associated with its transportation sector, it is critical that goals to increase the affordability and accessibility of these options and systems are pursued in tandem.

The Greater Worcester region supports four different Regional Transit Authorities, the Worcester Regional Transit Authority (WRTA), the Montachusett Regional Transit Authority (MART), the Northeast Connecticut Transit District (NECTD), and the Windham Region Transit District (WRTD). Below are service coverage maps for each of these RTAs.



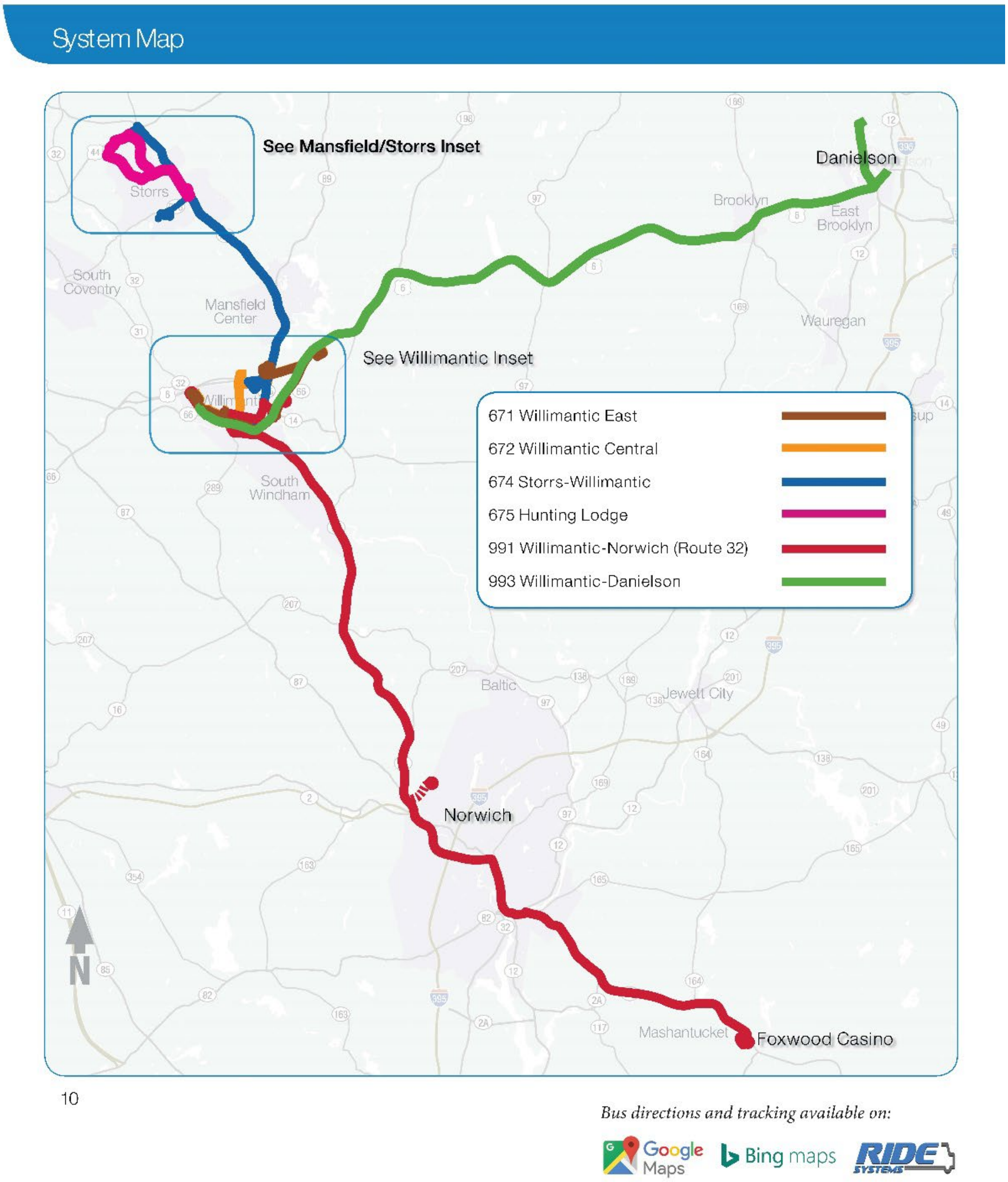
WRTA System Map[cxxix]



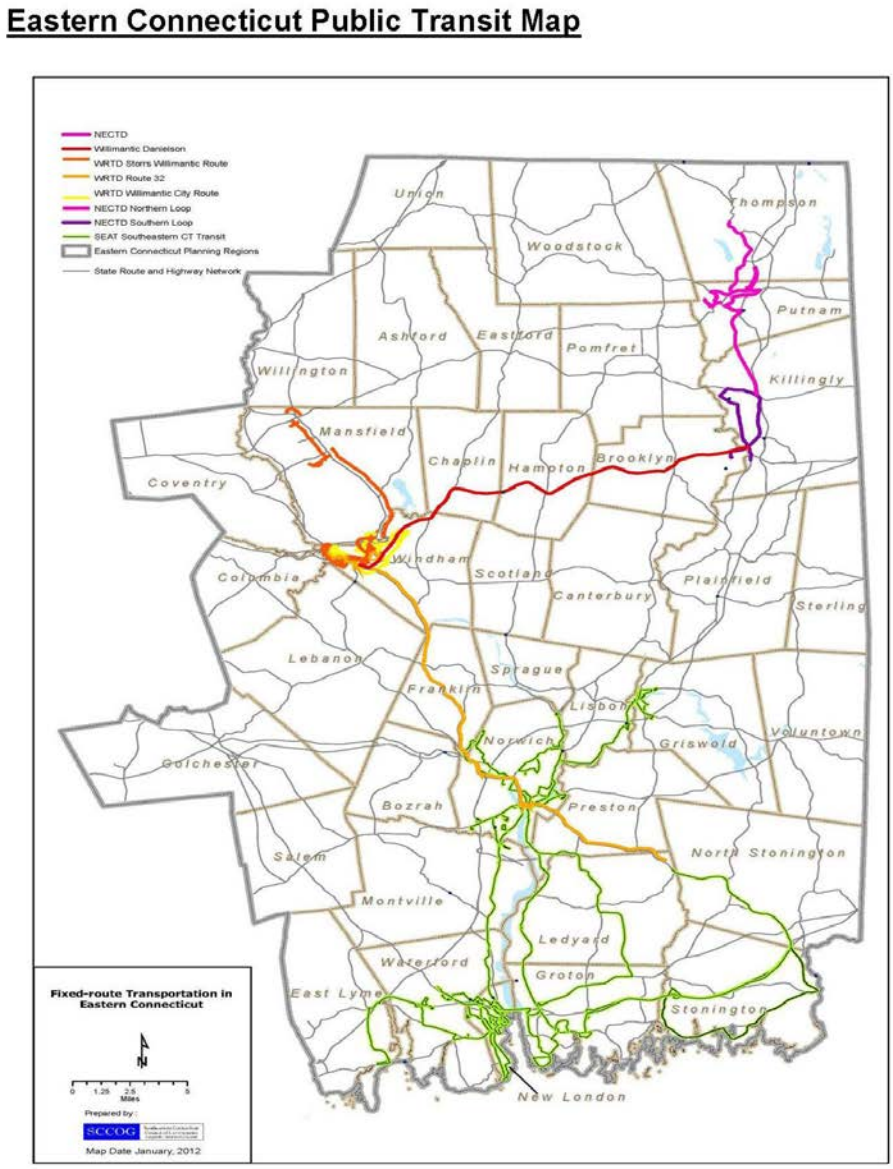
MART System Map[cxxx]

*The MBTA Commuter Rail Station at Wachusett has

opened since the creation of this map



WRTD System Map[cxxxi]



Eastern Connecticut Transportation Map

(including WRTD and NECTD in the north)[cxxxii]

*NECTD's Orange Line to Plainfield has been

launched since this map was made[cxxxiii]

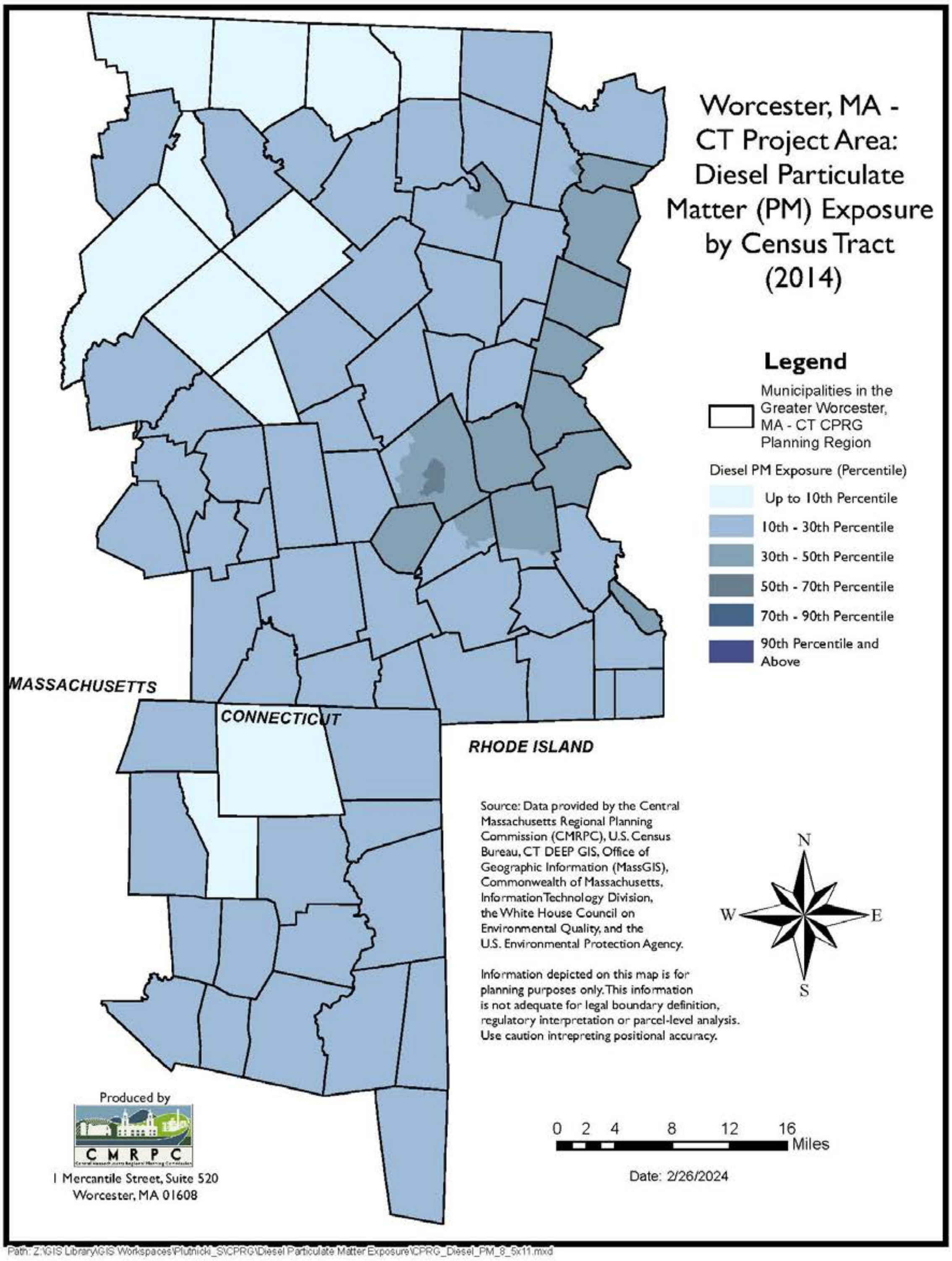
The below table shows the means of transportation to work for workers 16 years and older in the Worcester MA-CT MSA according to 2018-2022 American Community Survey Estimates. According to this data, around 75% of workers commute alone via personal vehicle. Substantial minorities of workers carpool or work from home in the region, but only approximately 4% of commuters in the region utilize public transport and active transportation to get to work.

Table 14: Means of Transportation to Work in the Worcester MA-CT MSA, 2018-2022

Means of Transportation to Work	Percentage of Workers 16 Years Old and Older
Car, truck or van: drove alone	74.3%
Car, truck, or van: carpooled	7.6%
Public Transportation	1.4%
Walked	2.5%
Bicycle	0.1%
Taxicab, motorcycle, or other means	1.8%
Worked from home	12.2%

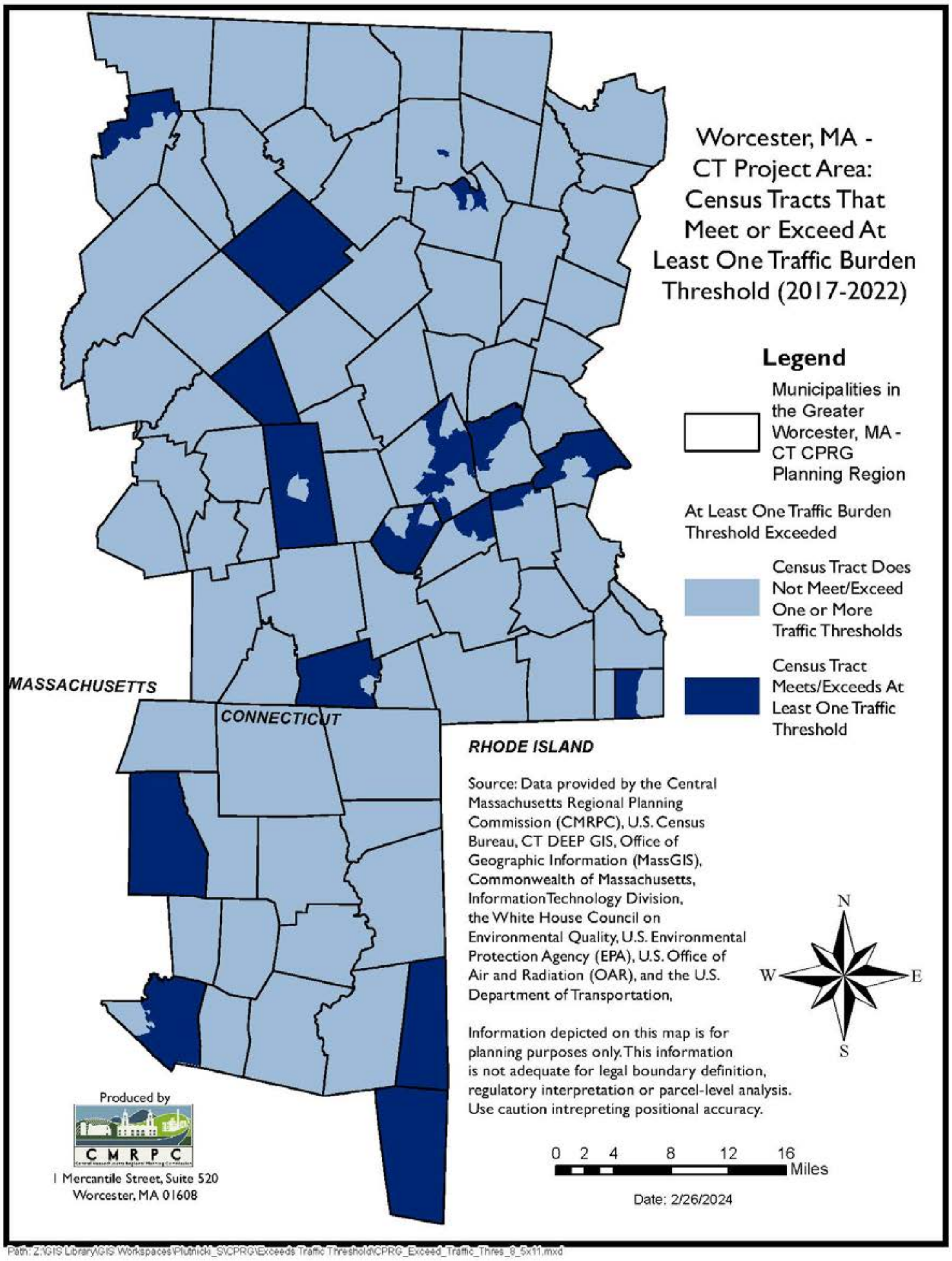
Source: 2022 ACS 5-Year Estimates[cxxxiv]

Within the region, diesel particulate matter levels in 2014 were highest in downtown Worcester; they were also higher in downtown Leominster, in other parts of Worcester, as well as in towns to the northeast, east, south, and southeast of Worcester than in other parts of the region.



cxxxv

The most traffic-burdened communities in the region between 2017-2022 included Census Tracts within the cities of Fitchburg, Leominster, Windham, and Worcester and Census Tracts within the towns of Ashford, Athol, Auburn, Blackstone, Dudley, Grafton, Hubbardston, Millbury, Oakham, Shrewsbury, Spencer, Sterling (CT), Voluntown, and Westborough.



cxxxvi

Communities with high traffic diesel particulate matter levels and with elevated levels of air pollution caused by traffic can greatly benefit from electric public transportation. Electric buses contribute to decreased localized air pollution and therefore increased resident health.[cxxxvii]

Community Engagement Workshops: Transportation Sector Results

Sector Prioritization Activity

During the Greater Worcester Region's Climate Pollution Reduction Strategies Public Workshop series, CMRPC asked attendees to vote on which of the six major climate polluting sectors they would like to see future investments funneled to. Attendees were given two "tickets" and were asked to place them into boxes corresponding to the sector(s) they would prioritize. Overall, the transportation sector received the highest number of investments.

Goal Prioritization Activity

The results of the activity in which workshop attendees prioritized the draft goals for the transportation sector and were able to share a draft goal of their own are shown below. Workshop attendees ranked the four draft goals and, if applicable, the goal they proposed from one to five, with one meaning highest priority and five meaning lowest priority. The table below shows the four draft goals ranked, with #1 being the goal that was on average ranked as the highest priority and #4 being the goal that was on average ranked as the lowest priority.

Goal / Option	Rank
Reduce overall vehicle travel demand and improve mobility for all modes of transportation (i.e., active transportation and transit).	1
Improve the operational efficiency of freight and fleet.	2
Improve fuel efficiency.	3
Electrify personal transportation networks and scale up fuel switching efforts.	4

Some main takeaways from the goals that workshop attendees proposed include:

- There is interest in creating more bike lanes and shared-use paths in the region.
- There is interest in improving public transportation options and service in the region, especially between major community centers and transportation hubs.
- There is interest in making communities more walkable and less car centric.

- There is interest in electrifying and developing infrastructure relating to both personal and public transportation; there are also concerns about these possibilities.

The goals proposed by attendees are covered in more general terms by the original draft goals.

The results of this activity show that reducing overall vehicle travel demand and improving mobility for all modes of transportation, including active transportation and transit, was clearly the draft goal that workshop attendees most highly prioritized on average. When adding up all the of the rankings from attendees, this goal's total "score" was over 50 points lower than the next highest-priority goal; it was very often ranked as the #1 or #2 goal by attendees.

The original draft transportation goals became the final transportation goals for the plan. All of them were highly prioritized by many workshop attendees and CMRPC did not receive a lot of feedback disagreeing with moving forward with them.

Feedback from Discussions

Participants provided much insightful feedback on the transportation sector during both group and one-on-one discussions at the GWPCAP workshops. This feedback can be grouped into six main categories: cyclist and pedestrian infrastructure, electric vehicles and EV charging stations, carpooling, public transit, school buses, and other feedback. Main takeaways for each of these categories are described below.

Cyclist and Pedestrian Infrastructure

- There is a need for more and higher-quality bike and pedestrian infrastructure in the region, such as improved sidewalks and protected bike lanes.
- The bike and rolling infrastructure in the region needs to be made safer, as bicyclists and rollers using routes frequented by cars is a safety issue.
- There is interest in bike and/or scooter sharing programs in the region.
- There is interest in increased E-bike infrastructure in the City of Worcester due to the city's hilly topography and accessibility and speed.

Electric Vehicles and EV Charging Stations

- There is a need to better distribute EV charging stations in the region and create a publicly accessible map of them so that varying geographies can equitably access these stations.
- There is a cost-burden for buying EVs for many low-income families, so providing them with funds / incentives to help them purchase EVs can alleviate this issue.
- There is interest in the purchase of EVs for municipal use.

- It is currently more difficult for renters to access EV chargers at their homes than homeowners, so a program to help renters access these chargers would be beneficial.
- A program should be set up to help employers build EV charging stations to be used by their employees.
- State and federal EV infrastructure programs should be used.
- EV charging stations on utility poles or run though cords over sidewalks are inexpensive and should be considered.
- EV charging stations.
- There is concern that EVs are inefficient due to their weight, cause greater amounts of particulate pollution through tire wear, and further entrench an unfavorable automobile-centric transportation system.
- There is interest in powering EVs with renewable energy.

Carpooling

- Increased carpooling can reduce emissions while increasing social connections in both rural and urban communities. Services such as Neighbors Helping Neighbors, Via as well as local colleges could collaborate with communities to enhance carpooling programs.
- Park and ride hubs should be built to encourage carpooling to important destinations, which reduces emissions.

Public Transit

- There is a need to increase public transit service to important destinations in both rural and urban parts of the region, both in terms of routes within communities to vital services and routes between transit hubs in different communities.
- There is a need for enhanced last-mile connections from the end points of transit routes to important destinations.
- There is interest in enhancing the frequency of public transportation routes in the region, their number and geographic spread. There is also interest in increasing the number and quality of bus shelters in the region.
- There is interest in creating more concentric and perimeter public transportation routes in the region to enhance transit service.
- There is inequity and injustice in the region about how some people, such as older adults, people with certain disabilities and/or medical conditions, and

people from historically marginalized socioeconomic backgrounds, cannot access the transportation services they need.

- Fare free public transit service is a positive development which helps easier travel for many people.
- Electrifying buses reduces idling emissions.
- There is interest in electric van / shuttle services that can complement existing services.
- There is interest in enhanced, and perhaps high-speed, rail service connecting the region to major cities in the northeast.
- There is interest in enhancing van service for senior citizens in the region through buying electric vans.

School Buses

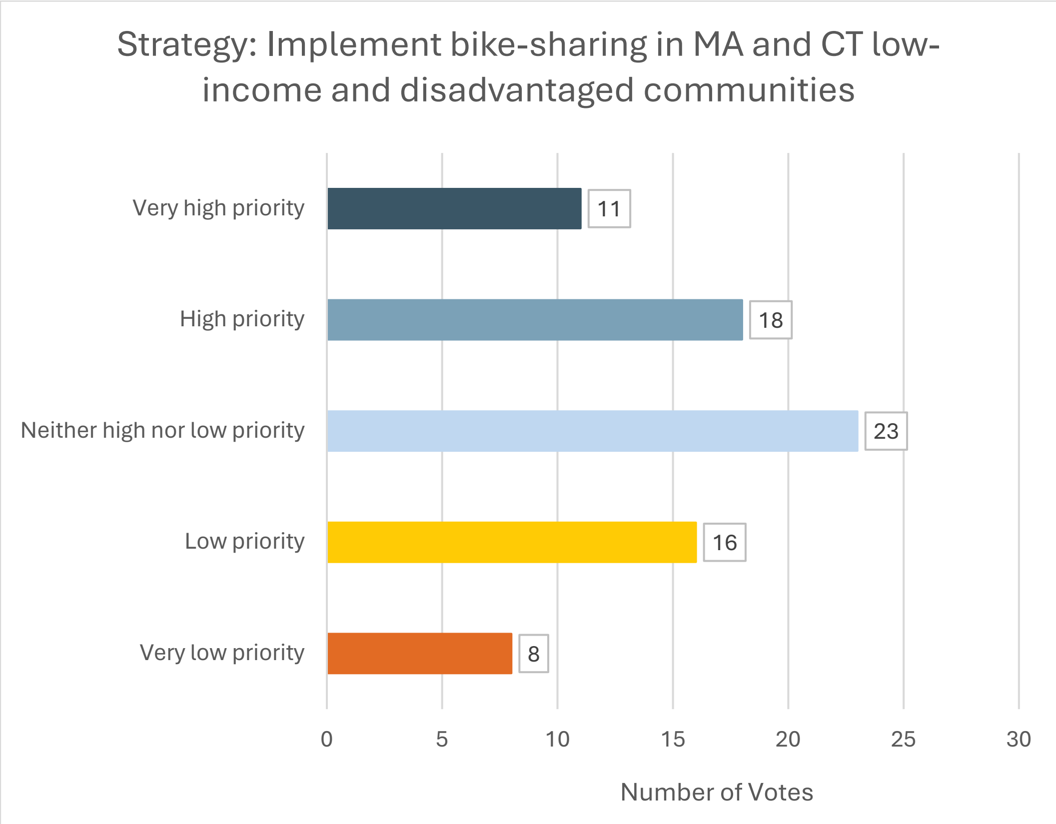
- There is interest in buying small electric school buses to increase the efficiency of the school bus system.
- Cutting fees for using school buses can increase school bus ridership and therefore reduce emissions from parents taking their kids to school in personal vehicles.

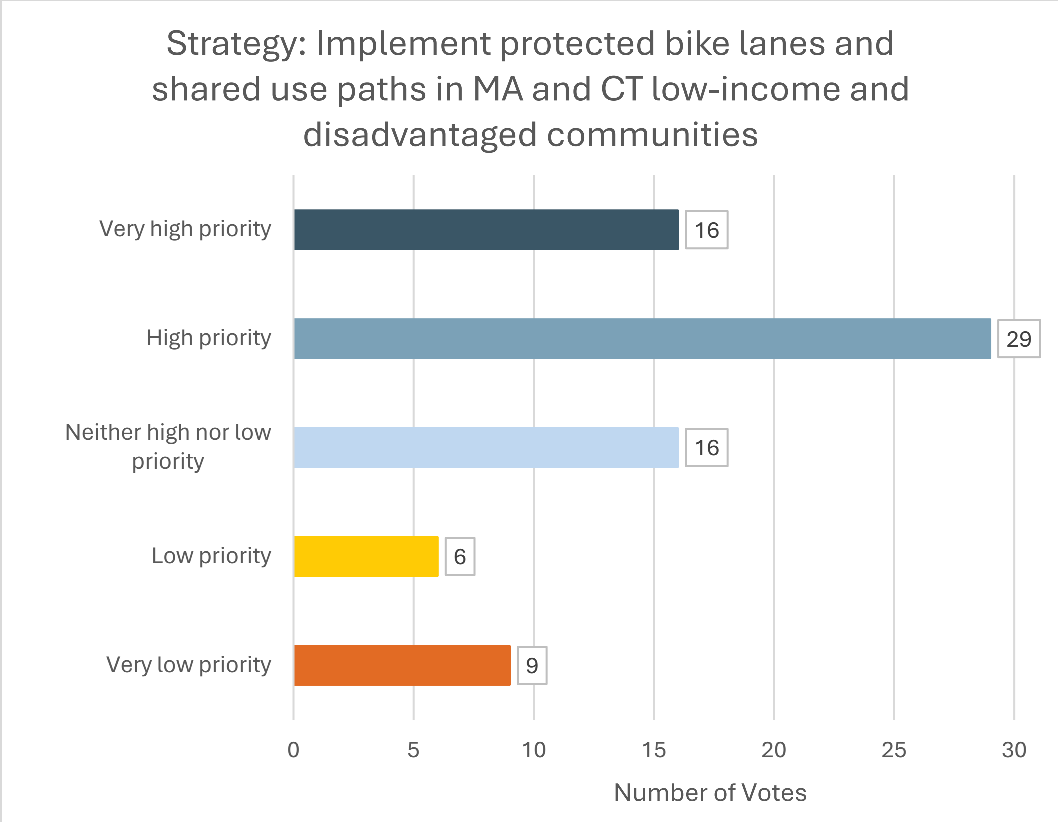
Other Feedback

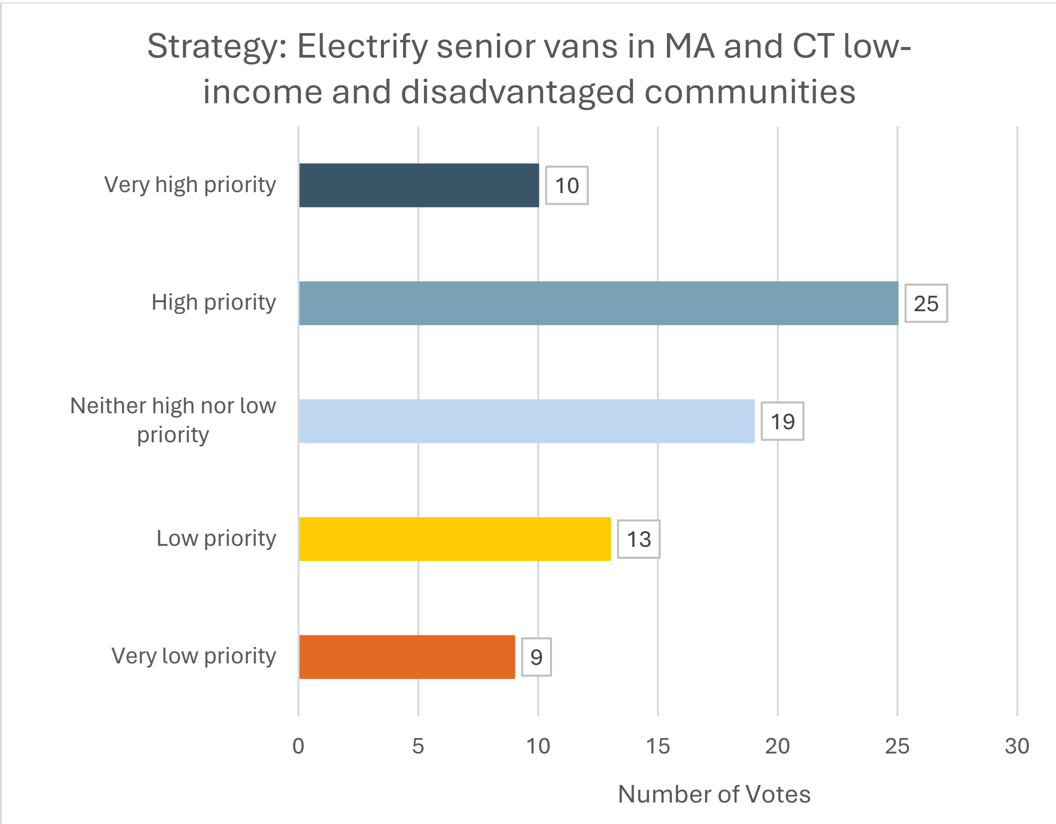
- There is concern about pollution caused by the excessive use of salt along roadways.
- There is concern about emissions from internal combustion engine vehicles.
- There is ongoing transportation planning work being undertaken within the region which should be built upon.
- There is interest in pursuing ways to reduce transportation demand through enhanced broadband service and increased work from home options.
- Freight railroads in the region should have better signage and should have more efficient and safer routes.

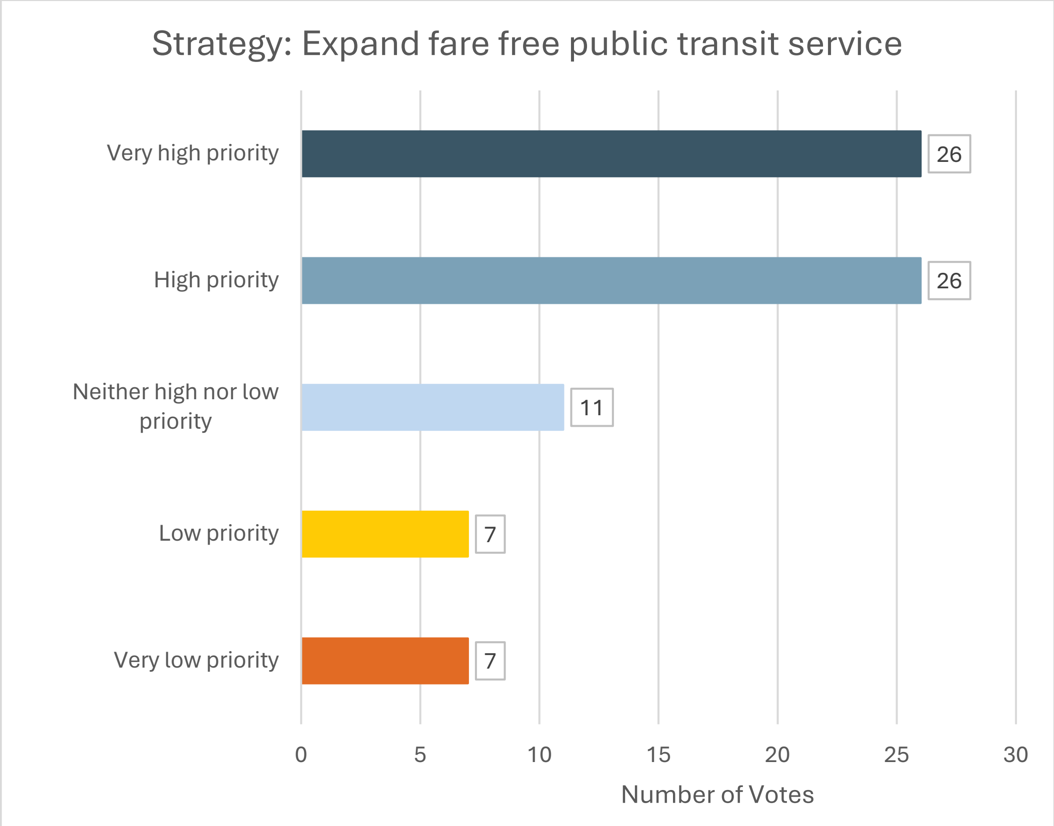
Strategy Prioritization

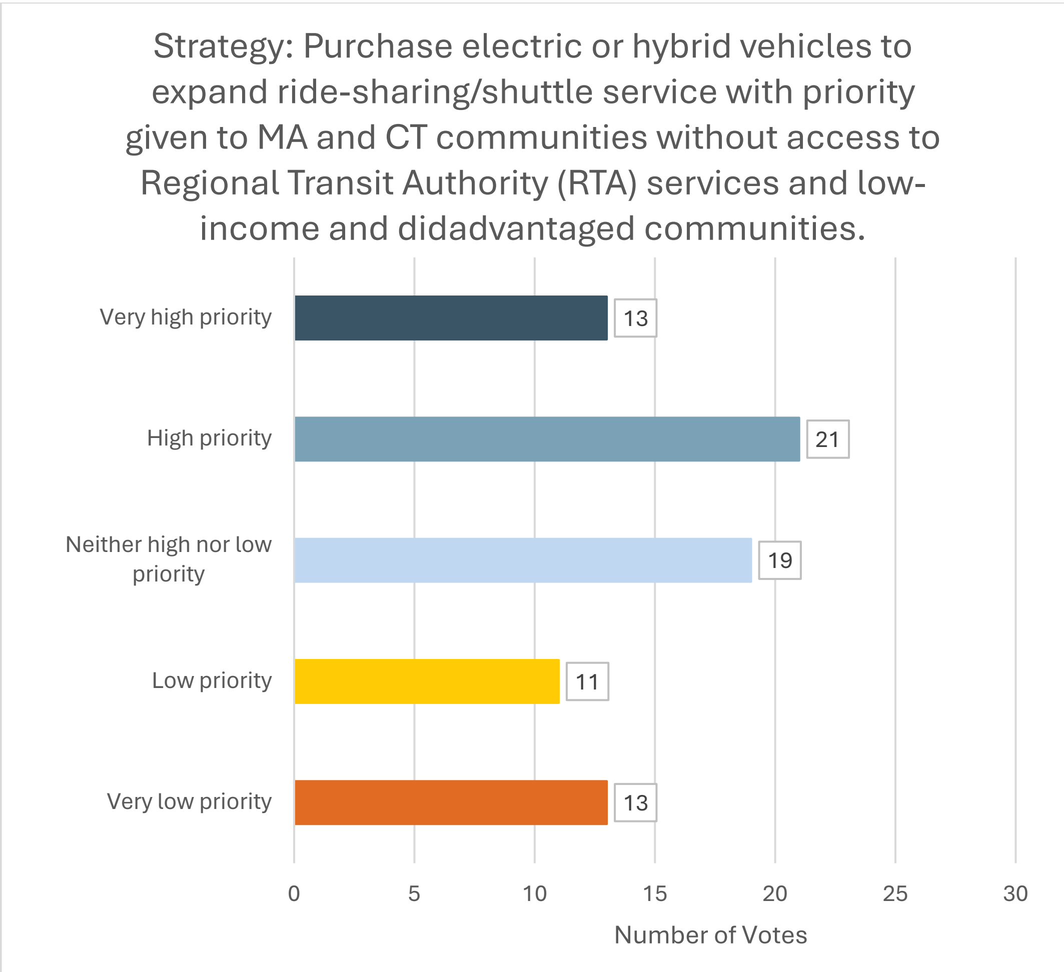
The results of the section of the public survey in which respondents prioritized the draft climate pollution reduction action strategies for transportation are summarized below.

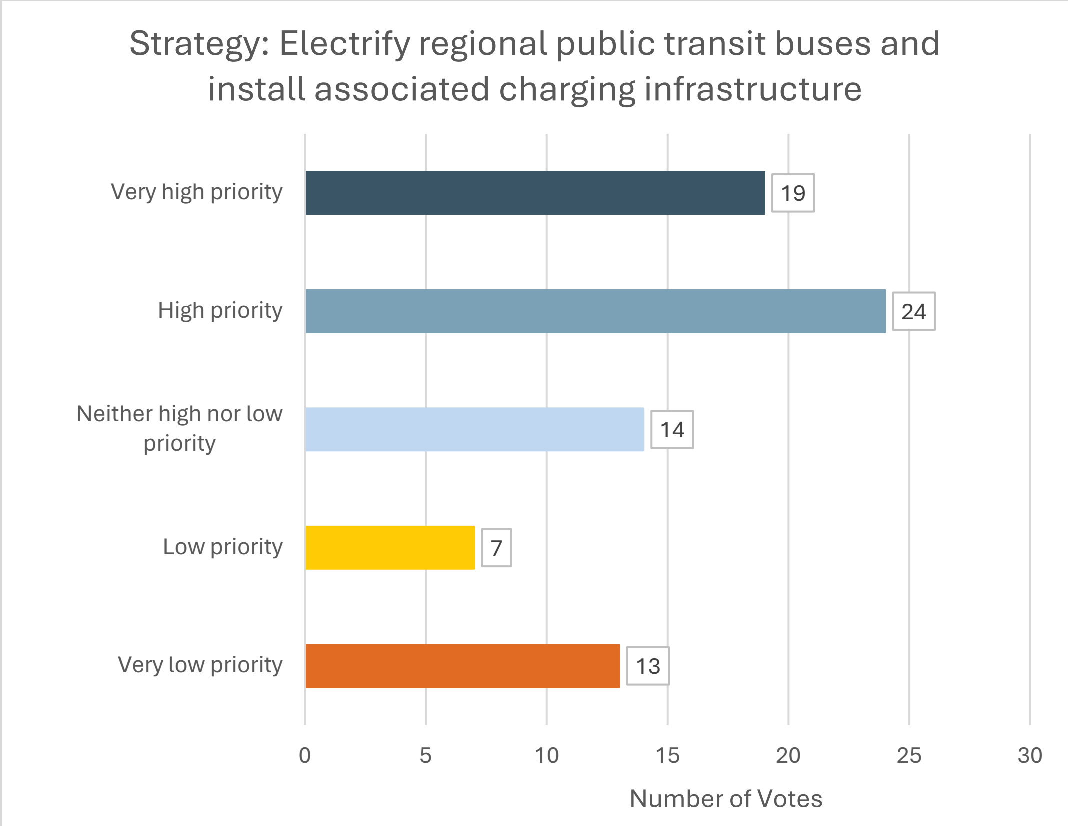



Strategy: Implement protected bike lanes and shared use paths in MA and CT low-income and disadvantaged communities
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
16
29
16
6
9
0
5
10
15
20
25
30
Number of Votes


Strategy: Electrify senior vans in MA and CT low-income and disadvantaged communities
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
10
25
19
13
9
0
5
10
15
20
25
30
Number of Votes


Strategy: Expand fare free public transit service
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
26
26
11
7
7
0
5
10
15
20
25
30
Number of Votes


Strategy: Purchase electric or hybrid vehicles to expand ride-sharing/shuttle service with priority given to MA and CT communities without access to Regional Transit Authority (RTA) services and low-income and didadvantaged communities.
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
13
21
19
11
13
0
5
10
15
20
25
30
Number of Votes



Main takeaways from the last question of this survey in which survey respondents could provide any other thoughts that they would like to share included:

- There is interest in funding studies and initiatives to expand EV charging infrastructure in the region and in promoting electric vehicles to reduce air pollution in urban areas.
- There is concern that electric vehicles may be bought before adequate charging infrastructure has been installed and grid capacity has increased. There is also concern that there will not be a plan for the disposal of electric vehicle batteries.
- There is concern about carcinogenic effects of coal-based driveway seal coating.
- There is concern about increased traffic, idling emissions, and safety issues related to bike lanes.

These results show that the transportation action which survey respondents most highly prioritized was expanding fare free public transportation service, as this action was ranked as very high priority or high priority by approximately 2/3^{rds} of respondents. The two other most highly prioritized actions by respondents were implementing protected bike lanes and shared-use paths in MA and CT low-income and disadvantaged communities and electrifying regional public transit buses and installing associated charging infrastructure. Notably, the specific draft transportation actions were on average not prioritized as highly by survey respondents as the draft actions for the other sectors, despite transportation as a sector being highly prioritized for investment by workshop attendees.

Transportation Sector: Goals, Strategies and Actions

Goals

1. Reduce overall vehicle travel demand and improve mobility for all modes of transportation (i.e., active transportation and transit) - **CRITICAL URGENCY**

2. Improve the operational efficiency of freight and fleet - **CRITICAL URGENCY**

3. Improve fuel efficiency - **CRITICAL URGENCY**

4. Electrify personal transportation networks and scale up fuel switching efforts - **CRITICAL URGENCY**

Table 15: Transportation Sector Priority Strategies

Goal	Strategy	Overall Priority	Public Priority	Estimated GHG Reductions (MT CO2e per year)	Municipal cost savings	Estimated Costs	LIDAC Benefits	Authority to Implement
1, 2	Expand fare-free public transit service	High	Very High / High	1,178	Low	High	High	RTAs and Local
1	Implement 30 miles of protected bike lanes and shared-use paths in LIDACs and EJ communities	Medium	High	299	Low	Medium	High	Local or State
1, 2, 3	Electrify regional public transit buses and install associated charging infrastructure	Medium	High	355	N/A	High	Low	RTAs, Private, Local, Regional School Districts
1	Implement bike-sharing in EJ communities	Low	Neutral	311	Low	Low	High	Local and/or Private
1, 2, 3	Electrify senior vans in EJ communities	Low	High	206	Low	Medium	High	RTAs, Private, and Local
1, 2, 3	Purchase 10 Electric or hybrid vehicles to expand ridesharing/shuttle service with priority given to communities without access to regional transit and EJ communities	Low	High	427	Low	Medium	Medium	Local, RTAs, and/or Private

Strategy Narratives

Strategy 1: Expand fare-free public transit service.

Overview

Fare-free operation of public transportation systems in the Greater Worcester region and a study to explore ways to permanently support fare-free service will be funded by regional stakeholders to reduce emissions and better serve the low-income and disadvantaged communities which rely on its services.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 1,178 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on the reduction in gasoline usage resulting from replacing personal vehicle use with bus use. They assumed 16% growth in bus trips for each year of fare free service, based on projected 16% growth in WRTA bus trips from fiscal year 2023 to fiscal year 2024 when service was fare free;[cxxxviii] in the 5th year of fare free service, it is estimated that an additional 271,533 unlinked passenger trips would be made based on the 334,962 unlinked passenger trips being taken in December 2022. Gasoline savings were calculated by assuming each trip on a fare free bus eliminates 10.7 miles of travel from a gasoline vehicle with a fuel efficiency of 21.9 miles per gallon.[cxxxix] These gasoline savings multiplied by 271,533 trips results in savings of 132,842 gallons of gasoline. It was also assumed that the bus fuel usage did not change in terms of either amount or fuel type.

Benefits and Challenges

The expansion of fare free public transit service in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. Fare free service incentivizes mode-shift from personal automobiles to public transit services which emit far fewer greenhouse gas emissions per rider. [cxl]

In addition to direct climate-related benefits, there are several co-benefits of fare free public transit service for LIDACs and Massachusetts and Connecticut designated EJ communities. The elimination of fares removes the cost barrier to enhanced mobility in accessing vital services such as education and healthcare for low-income community members and frees up their limited monetary resources for other needs.[cxli] Fare free service, if funded by other sources, saves money for municipalities and RTAs, as they would be reimbursed for lost far revenues; they could use these savings to invest in other programs which benefit low-income and disadvantaged community members, such as transit coverage and frequency expansion and social programs. Transit efficiency is also increased by fare-free service, as buses no longer must wait for riders to pay before entering and therefore have an easier time reaching their destinations on time. Increased transit ridership, which has already been experienced by the WRTA during the time they have offered fare-free service, also may lead to increased public demand for transit and support for transit-oriented development patterns that lead to reduced emissions.[cxlii]

A major challenge is ensuring that fare-free public transit is a financially sustainable model in the long term for RTAs and municipalities. Creating a study to explore ways to permanently support fare-free service in the Greater Worcester region can be a first step in achieving this challenge. This study can also be a workforce development opportunity for members of low-income and disadvantaged communities who are enthusiastic about public transportation equity.

This action will lead to low municipal cost savings caused by a more efficient transportation network. It will also have prohibitive costs due to the substantial number of foregone fares that it will lead to.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, expanding fare-free public transit service in the region is ranked as high priority for this plan. Regional Transit Authorities have high authority to implement this action, with aid and support from local governments. The IRA funding will be used to directly reimburse Regional Transit Authorities for lost fare revenues resulting from fare free service.

Strategy 2: Implement 30 miles of protected bike lanes and shared-use paths in LIDACs and EJ communities.

Overview

Regional stakeholders will work with LIDACs and Massachusetts and Connecticut designated EJ communities in the Greater Worcester region to design and implement protected bike lanes and shared use paths between targeted residential, employment, commercial, and recreational centers. These bike lanes will be accessible for cyclists with disabilities.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 299 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on the reduction in fossil fuel usage resulting from use of the expanded network of protected bike lanes and paths. They identified the population that already bikes to work from Census data, which includes 0.4% of Worcester County and 0.6% of Windham County.[cxliii] These percentages were applied to the 7 municipalities with LIDACs in the region based on the state they are in and were increased by 15% to account for additional users –this increase in users was estimated based on Blue Bike data.[cxliv] It was assumed that the 30 miles of new bike corridors would be split evenly between the 7 communities and that each person would use the path twice per week, or 104 times per year.

Benefits and Challenges

Increasing the mileage of protected bike lanes and shared-use paths in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. This infrastructure makes it safer and easier for people to choose walking, rolling, and cycling as everyday mobility options; it will therefore lead to less personal vehicle trips and a resulting decrease in emissions.[cxlv]

In addition to direct climate-related benefits, there are several co-benefits of protected bike lanes and shared use paths for LIDACs and Massachusetts and Connecticut-designated EJ populations. Biking and rolling along protected bike lanes and shared use paths as well as walking and jogging along shared use paths can be enjoyable recreational experiences; they can help deepen people's connection with nature and with each other. [cxlvi] These experiences also contribute to people's fitness and can help reduce obesity rates and other health problems in communities that these corridors are nearby.[cxlvii] There should be workforce development opportunities for LIDAC and EJ community residents in planning, designing, constructing, and maintaining these protected bike lanes and shared use paths. There also can be economic development and tourism opportunities for communities which are near these corridors if they are well planned and can be used to easily connect to and between businesses and lodging.[cxlviii] This infrastructure also greatly increases the safety of cyclists and rollers, as it separates them from cars, encourages slower driving, and lowers the probability of dangerous accidents.[cxlix]

A major challenge for successfully implementing an enhanced network of protected bike lanes and shared-use paths is ensuring that they do not lead to increased conflicts between cyclists and rollers, especially e-bike users, and the drivers of cars and buses as well as pedestrians. It is best practice to use Complete Streets design elements that clearly indicate the rights of way of cycling and rolling corridors when they cross streets designed for automobile traffic.[cl] It is also advisable to either disallow parking on routes with protected bike lanes or sufficiently separate protected bike lanes from parking spaces to prevent conflicts when drivers get out of their vehicles.[cli] In addition, it is preferable to have physical barriers between cycling and pedestrian pathways to prevent dangerous crashes.[clii] Including clear signage along shared use paths and indicating that walking, jogging, and other slower-speed uses is allowed is also a good idea, as it reminds cyclists, rollers, and other higher-speed users to take precautions.[cliii] Bicycle signaling at crossings is also best practice.[cliv]

This action will lead to low municipal cost savings caused by a more efficient transportation network. It will also have medium costs associated with the design and construction of the protected bike lanes and shared-use paths.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, implementing 30 miles of protected bike lanes and shared-use paths in LIDACs and EJ communities in the region is ranked as medium priority for this plan. Local governments have high authority to implement this action along locally controlled rights-of-way, while state governments have high authority to implement this action along state-controlled rights-of-way. The IRA funding will be used for design, construction, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work which help in achieving this action.

Strategy 3: Electrify regional public transit buses and install associated charging infrastructure.

Overview

Regional stakeholders will buy electric buses and install electric bus charging systems used by regional transit authorities and school bus providers.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 355 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on gallons of diesel saved and increased electricity usage resulting from bus electrification. They calculated the decreased diesel usage and increased electricity usage resulting when 5 diesel buses are replaced with 5 electric buses. It was assumed that a battery electric bus uses 2 kWh/mile and travels an average of 25,624 miles per year, and these assumptions were based upon data on the WRTA's use of electric buses.[clv] A value of 3.7 miles per gallon was used for the average diesel transit bus fuel efficiency in 2017.[clvi]

Benefits and Challenges

Electrifying regional public transit buses and installing charging infrastructure for them in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. Electric buses cause significantly less greenhouse gas emissions than fossil fuel powered buses if the electricity they use is generated from renewable sources; they are also more efficient than fossil fuel powered buses even if the electricity they use is generated by the burning of fossil fuels.[clvii] Electrifying regional public transit buses will also increase localized air quality in areas surrounding bus routes, as they do not release tailpipe emissions of air pollutants like internal combustion engine buses do.[clviii]

In addition to direct climate-related benefits, there are several co-benefits of electrifying regional public transit buses and installing charging infrastructure for LIDACs and Massachusetts and Connecticut designated EJ communities. Members of LIDACs and EJ communities should have workforce development opportunities in designing and installing the charging infrastructure for the buses. If these improvements to RTA fleets are funded by outside sources, RTA resources are freed to invest in other programs which helps LIDAC and EJ community members, such as transit coverage and frequency expansion as well as more expansive bus shelter networks.

There are several challenges with electrifying regional public transit buses. Electric vehicle materials are often sourced from manufacturers which violate the human and economic rights of their workers.[clix] Electric buses have also been shown to be at risk of catching fire.[clx] Regional stakeholders should be aware of these issues when considering the costs and benefits of electric bus purchases. They also should train regional transit and public safety workers on how to mitigate and respond to fire hazards related to electric buses.

This action will lead to low municipal cost savings caused by less air pollution-related illnesses. It will also have prohibitive costs associated with the acquisition of electric buses and the design and construction of electric bus charging stations.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, electrifying regional public transit buses and installing associated charging infrastructure in the region is ranked as medium priority for this plan. Regional Transit Authorities and school bus providers, including local and regional school districts and private entities, have high authority to implement this action. The IRA funding will be used for procurement management work in buying vehicles and other materials, charging station design work, charging station construction, technical assistance, public/other stakeholder engagement work, project management, and grant administration which help in achieving this action.

Strategy 4: Implement bike-sharing in EJ communities.

Overview

Regional stakeholders will launch a bike-sharing program in low income and disadvantaged communities in the Greater Worcester region (in both MA and CT). A public-private partnership will be considered in buying and maintaining the bikes, and this service will also preferably be fare-free. Cycles designed to be used by people with disabilities will be included in this service.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 311 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on gallons of gasoline saved per bike trip. They assumed an average of 1.85 miles per bike trip, using 2017 American Community Survey 1-Year Estimates data about the populations commuting to work via bicycle.[clxi] This included 0.4% of Worcester County and 0.6% of Windham County.[clxii] The use of the bike share service was apportioned to the populations of the 7 municipalities with LIDACs in the region, and the percentage of the population commuting to work by bicycle was assumed to increase to 1% of these municipalities' populations with the introduction of a bike share service. It was also assumed that the bike share would be used once per week, or 52 times per year, by each person.

Benefits and Challenges

Establishing a bike-sharing program in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. Free or otherwise easily accessible bike share service incentivizes cycling as an everyday mobility option and will therefore lead to less personal vehicle trips and a resulting decrease in emissions.[clxiii]

In addition to direct climate-related benefits, there are several co-benefits of bike-share service for LIDACs and Massachusetts and Connecticut designated EJ communities. As was mentioned under Strategy 2 for the transportation sector, cycling can be an enjoyable recreational experience that can help deepen people's connection with nature and with each other. Cycling also contributes to people's fitness and this service can help reduce obesity rates and other health problems among riders from low-income and disadvantaged communities who use it.[clxiv] Establishing this service as free or distributing passes for freely accessing the service to residents of LIDACs and Massachusetts and Connecticut designated EJ communities removes cost barriers to mobility in accessing vital services such as education and healthcare and frees up people's limited monetary resources for other needs.[clxv] There should be workforce development opportunities for LIDAC and EJ community members in operating this service and maintaining cycling infrastructure that goes along with it.

A major challenge in setting up a successful bike share service is having the infrastructure to support safe and convenient riding for cyclists of varying skill levels. The protected bike lanes and shared use paths which are the focus of Strategy 2 are the backbone of a safe and convenient cycling infrastructure network. Other important infrastructure that supports safe and convenient cycling includes bike parking, bike maintenance stations, and signage that helps cyclists, pedestrians, and motorists take precautions.[clxvi] It is best practice for bike parking to hold bikes in positions where they can be securely locked, well-supported, to be easy to use, and to be able to accommodate different types of bikes; post-and-ring and inverted U bike racks are good bike parking infrastructure options.[clxvii]

This action will lead to low municipal cost savings caused by a more efficient transportation network. It will also have low costs associated with the acquisition of cycles, the design and construction of bike parking and bike maintenance stations, and the operation of the bike share service.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, implementing bike-sharing in LIDACs and EJ communities in the region is ranked as low priority for this plan. Local governments and/or private entities have a high authority to implement this action, either separately or jointly in a private-public partnership. The IRA funding will be used for procurement management in buying cycles and other materials, design and construction of bike parking, bike maintenance stations, and signage, technical assistance, public/other stakeholder engagement work, project management, and grant administration which help in achieving this action.

Strategy 5: Electrify senior vans in EJ communities.

Overview

Regional stakeholders will buy electric vans to be used for transportation by councils on aging, senior centers, and other senior transportation services in LIDACs and Massachusetts and Connecticut designated EJ communities in the Greater Worcester region.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 206 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on gallons of gasoline saved. They based their calculations on data about fuel use and miles travelled by vehicles used by the Groton Council on Aging.[clxviii] It was estimated that the Groton COA's vehicles used 2,343 gallons of gasoline and traveled 20,258 miles in a year, and it was assumed that the Groton COA uses two vehicles. This equates to 1,172 gallons and 10,129 miles per vehicle and, when applied to 20 vans, results in a gasoline savings of 23,432 gallons and a use of 141,808 kWh per year. These figures were calculated assuming electricity use of 0.7 kWh/mile for a large electric passenger van.[clxix]

Benefits and Challenges

Electrifying senior vans within Environmental Justice communities in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. Electric vans cause significantly less greenhouse gas emissions than fossil fuel powered vans if the electricity they use is generated from renewable sources; they are also more efficient than fossil fuel powered vans even if the electricity they use is generated by the burning of fossil fuels.[clxx] Electrifying senior vans will also increase localized air quality in areas surrounding the vans' service areas, as they do not release tailpipe emissions of air pollutants like internal combustion engine vans do.[clxxi]

In addition to direct climate-related benefits, there are several co-benefits of electrifying senior vans for LIDACs and Massachusetts and Connecticut designated EJ communities. If these improvements to senior van fleets are funded by outside sources, senior van operator resources are freed to invest in other programs which benefit the older adults who they serve, such as increasing the number of vans in a service's fleet, the number of drivers a service hires, a service's coverage area, and/or a service's hours of operation. There can be workforce development opportunities for LIDAC and EJ community members in filling new driver positions that may open if these services expand.

In addition to the issues with ethically sourcing electric vehicle parts, a major issue in successfully implementing electrification of senior vans in the region is coordinating the process, as there are several different senior van operators in the region, including SCM Elderbus, MART services, NECTD Services, WRTD services and local Councils on Aging. Regional stakeholders who oversee this process should skillfully balance the needs and consider concerns of these different operators. Another challenge in ensuring the successful implementation of these electric senior vans is making sure that charging infrastructure for these vans are placed in locations which aid in the efficiency of these services.[clxxii]

This action will lead to low municipal cost savings caused by a more efficient transportation network and less air pollution-related illnesses. It will also have medium costs associated with the acquisition of electric vans and the design and construction of electric van charging stations.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, electrifying senior vans in LIDACs and EJ communities in the region is ranked as a low priority for this plan. Senior van operators, including local governments, regional transit authorities, private entities, and partnerships between these three types of entities, have high authority to implement this action. The IRA funding will be used for procurement management work in buying vehicles and other materials, charging station design work, charging station construction, technical assistance, public/other stakeholder engagement work, project management, and grant administration which help in achieving this action.

Strategy 6: Buy 10 Electric or hybrid vehicles to expand ridesharing/shuttle service with priority given to communities without access to regional transit and EJ communities.

Overview

Regional stakeholders will purchase vehicles to expand ridesharing and shuttle service in communities without access to regional transit service and LIDACs. This service will preferably be fare-free. It will be accessible for people with disabilities.

Emissions Reduction Contribution

To calculate an emissions reduction for this action strategy of 427 MTCO2e per year when the action is achieved, Weston and Sampson took the following steps. They assumed that the emissions reductions for this action strategy are based on gallons of gasoline saved and increased electricity usage resulting from the addition of these electric vehicles to the regional transportation system. They calculated the decreased gasoline usage and increased electricity usage associated with the addition of 10 electric shuttles buses to the regional transportation system which use 0.7 kWh/mile and travel an average of 21,117 miles per year; these estimates were based on data regarding WRTA usage of shuttles.[clxxiii] It was assumed that for every ride there would be 2 people in the shuttle, that each trip would be an average of 10.7 miles long, and that gasoline vehicles being placed have a fuel efficiency of 21.9 miles per gallon; these estimates were based on 2017 vehicle census estimates.[clxxiv] These numbers result is a savings on 19,310 gallons of gasoline per year.

Benefits and Challenges

Establishing new electric vehicle ridesharing and shuttle services within communities in the Greater Worcester region will contribute to reduced greenhouse gas emissions, and therefore reduced climate pollution vulnerability and climate-related hazard impacts. Electric cars, vans, and buses cause significantly less greenhouse gas emissions than fossil fuel powered cars, vans, and buses if the electricity they use is generated from renewable sources; they are also more efficient than fossil fuel powered cars, vans, and buses even if the electricity they use is generated by the burning of fossil fuels.[clxxv] Mode-shift from fossil-fuel powered personal vehicles to these electric ride-share vehicles and shuttles will also increase localized air quality in areas surrounding ride-share service areas and shuttle routes; these electric vehicles do not release tailpipe emissions of air pollutants like internal combustion engine cars, vans, and buses do.[clxxvi]

In addition to direct climate-related benefits, there are several co-benefits of establishing electric vehicle ridesharing and shuttle services for LIDACs. Establishing these services as free or distributing passes for freely accessing these services to residents of LIDACs removes cost barriers to mobility and frees up people's limited monetary resources for other needs. These services also will allow people to make trips by shuttle or ride-share vehicle that previously have been unable to be made without using a personal vehicle or expensive ride-sharing service. There should be workforce development opportunities for residents of LIDACs in operating these services, driving vehicles for these services, and maintaining these services' vehicles.

In addition to the issues with ethically sourcing electric vehicle parts, key issues with successfully establishing new electric vehicle ride-sharing and shuttle services within communities in the region include deciding where it is best to establish fixed-route versus non-fixed route services and deciding how these services and their associated charging infrastructures will fit with each other. It is preferable to establish fixed-route shuttle services along corridors which currently lack transit service and which see large volumes of personal vehicle traffic.[clxxvii] It is preferable to establish non-fixed route ride share services in areas which currently lack transit service but which do not have especially highly trafficked corridors.[clxxviii] In addition, it is vital that charging infrastructure for these shuttles and ride-sharing vehicles are placed in locations which aid in the efficiency of these services.[clxxix]

This action will lead to low municipal cost savings caused by a more efficient transportation network and less air pollution-related illnesses. It will also have medium costs associated with the acquisition of electric vehicles and the design and construction of electric vehicle charging stations.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, transportation disadvantages, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Review of Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, buying 10 Electric or hybrid vehicles to expand ridesharing and shuttle services in the region is ranked as low priority for this plan. Local governments, regional transit authorities, private entities, and partnerships between these three types of entities have high authority to implement this action. The IRA funding will be used for procurement management work in buying vehicles and other materials, charging station design work, charging station construction, technical assistance, public/other stakeholder engagement work, project management, and grant administration which help in achieving this action.

Electricity

Electricity

Electricity is a critical lifeline for a functioning modern-day community in the Worcester MA-CT MSA. Electricity powers our lights and streetlights, cooling, and ventilation, chargeable electronic devices, hot water in our pipes, often our home heating, and much more. This is the energy charges critical, life-saving necessities such as medical technology, the lights in a hospital or school, or the air conditioning cooling a senior living facility through the summer.

The energy it takes to make electricity needs to come from somewhere. Humans use materials found on our planet to produce energy when they are burned. These elements include fossil fuels, such as oil, natural gas, and coal. Other ways to produce electricity do not require combustion of fossil fuels, such as harnessing wind or solar power.

How does the electricity sector contribute to climate pollution emissions?

Greenhouse gas emissions are released into the atmosphere when humans combust fossil fuels to generate electricity. Today, humans across the world, and throughout the Worcester MA-CT MSA, generate most of our electricity through thermal power plants. To produce electricity with these plants, fossil fuels, such as natural gas, are harvested from the earth's reserves and are combusted to create a chain of reactions resulting in generation of electrical energy. When people use fossil fuels to generate electricity in these power plants, excessive quantities of greenhouse gases such as carbon dioxide are released into the atmosphere, amplifying the greenhouse effect far beyond its natural levels.[clxxx]

On the other hand, renewable energy sources that do not require fossil fuel combustion (wind power, solar power and more), do not directly emit greenhouse gases into the atmosphere to produce electricity. The key to preserving the human right to electricity without releasing heat-trapping gases into our atmosphere, is moving away from climate-polluting fossil fuels to power electricity, and investing in renewable energy that does not pollute the climate.

Emissions Reduction Contribution

Within the Greater Worcester Region's Stationary Energy and Electricity Sector there are three major subsectors: residential buildings; commercial and institutional buildings and manufacturing industries; and construction. Within these three subsectors, there are various sources of emissions. These sources include electricity, electricity transport and delivery (T&D), fuel oil, natural gas, natural gas distribution losses, and off-road (various fuels). In the Greater Worcester Region, electricity generation and electricity transport and delivery are both responsible for a sizable portion of emissions from the residential building's subsector and the commercial, institutional, and industrial buildings subsector. Specifically, electricity generation and electricity transport and delivery from the Region's residential, commercial, institutional, and industrial contributed nearly 1.5 million metric tons of carbon of carbon dioxide equivalent emissions (CO2e) in 2017.[clxxxi]

Regional Context

Massachusetts

Electricity generation contributes 20% of the state of Massachusetts's total greenhouse gas emissions.[clxxxii] Natural gas is currently the leading fuel source used to produce electricity in the state. According to the United States Energy Information Administration (US EIA), in 2022, 75% of electricity produced in the state was generated using natural gas. But Massachusetts has also taken strides to reduce other fossil fuels' use. As of 2017 and 2019 respectively, Massachusetts no longer produces electricity using coal or nuclear power. The state has also begun efforts to decrease climate pollution by closing oil-powered electrical power plants and producing that electricity with natural gas or renewables.[clxxxiii]

Luckily, Massachusetts is a leader in the use of renewable energy to generate electricity. In 2022, a total of 15% of electricity was generated with renewables, including wind, all-scale utility solar, geothermal, and biomass.[clxxxiv] In the state's Clean Energy and Climate Plan (2022), Massachusetts has set goals to continue to decarbonize the electrical grid, decreasing fossil fuel use and increasing renewable energy utilization in electricity generation.[clxxxv] Despite leading in renewables, Massachusetts still has a way to go to decarbonization, with around three quarters of electricity production still coming from natural gas.

Connecticut

Like Massachusetts, Connecticut no longer uses coal in electric power plants and does use mainly natural gas for electricity generation. According to the US EIA, in 2022, Connecticut produced 56% of the state's electricity with natural gas. However, unlike Massachusetts, Connecticut does also use nuclear power for electricity generation as well. The state's singular nuclear power plant, the Millstone Plant, produced 38% of the state's electricity demand in 2022. Biomass-fueled petroleum-fired and hydro-electric power generated 3% of electricity in the state in the same year. Finally, solar power generated 3% electricity in 2022, and wind generated less than one percent.[clxxxvi] Connecticut has started to use renewable energy to produce electricity, but with 94% of electricity coming from natural gas and nuclear, the state has a long road ahead to clean electricity.

Worcester MA-CT MSA

Weston and Sampson created a snapshot of data to reflect the greenhouse gas emissions associated with the electricity production of the Worcester MA-CT Metropolitan Statistical Area. The table below shows the emissions associated with electric generation, transport, and delivery.

Table 16: Electric Generation, Transport, and Delivery Emissions

Subsector	Energy Category	Total CO2 Emissions	Total CH4 Emissions	Total N2O Emissions
		(MT CO2)	(MT CH4)	(MT N2O)
Residential Buildings	IOU Residential	1017993.01	51.09	6.99
	CCA Residential	-	-	
	Muni Residential	64790.42	5.61	0.77
	All Res. T&D Losses	28790.22	4883.71	0.3
	Fuel Oil	980768.39	39.78	
	EV Adjustment	-1057.82	-0.1	
	Res. Buildings Total	2091284.22	4980.09	8.06
Commercial & Institutional Buildings & Manufacturing Industries	IOU Non-Residential	1734023.69	74.44	10.2
	CCA Non-Residential	-	-	
	Muni Non-Residential	57688.11	4.99	0.69
	All C&I T&D Losses	42369.98	9249.06	0.45
	Fuel Oil	249155.39	9.34	
	EV Adjustment	-227.17	-0.02	
	Off-road	186148.35	103.05	
	C&I Buildings Total	2269158	9441	11
Construction	Off-road	157624.09	6.76	
	Construction Total	157624.09	6.76	
All Stationary Energy Subsectors		4360442.58	14420.94	19.4

Data Source: Data Source: Worcester, MA-CT Metropolitan Statistical Area Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[clxxxvii]

As shown in the table above, the Worcester MA-CT MSA is still responsible for greenhouse gas emissions, despite making strides to reduce climate pollution by no longer using coal. The MSA also still relies on fossil fuels like natural gas and a small amount of oil to produce electricity. Greenhouse gases broken down by residential and commercial and institutional uses are reflected below.

Table 17: Residential and Commercial/Industrial Emissions

Subsector	**CO2 Equivalent Emissions (MT CO2e)**	**% of Emissions from Electricity Generation**
Residential Electric Emissions	582,173.74	41%
Commercial, Institutional, & Industrial Electric Emissions	841,666.02	59%
Total:	**1,423,839.76**	**100%**

Data Source: Data Source: Worcester, MA-CT Metropolitan Statistical Area Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[clxxxviii]

Residential electricity generation accounts for 41% of emissions from electricity generation, while commercial and industrial sectors account for 59% of electricity-related emissions. As shown below, emissions from the electricity and stationary energy sectors combined accounted for 45% of all greenhouse gas emissions in the MSA in 2017.[clxxxix]

Table 18: Emissions from All Climate Polluting Sectors Within the Worcester, MA – CT MSA (2017)

Sector	CO2 Equivalent Emissions (MT CO2e)	% of total
Stationary Energy	3,435,815	31%
Electricity	1,493,965	14%
Transportation	5,627,781	51%
Waste	456,055	4%
Agriculture	34,217	0%
Gross Emissions	11,047,832	100%
Net Emissions	9,054,457	
Stationary & Electrical Energy Combined	4,929,780	45%

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cxc]

Community Engagement Workshops: Electricity Sector Results

Sector Prioritization Activity

At each of the community engagement workshops, participants were asked to rank the order to which they prioritized each of the sectors, as well as the goals and action strategies created under each sector. First, participants voted on their top two priorities out of each of the greenhouse gas emitting sectors. Results of all the workshops showed that the electricity sector ranked second highest priority (tied with the waste sector).

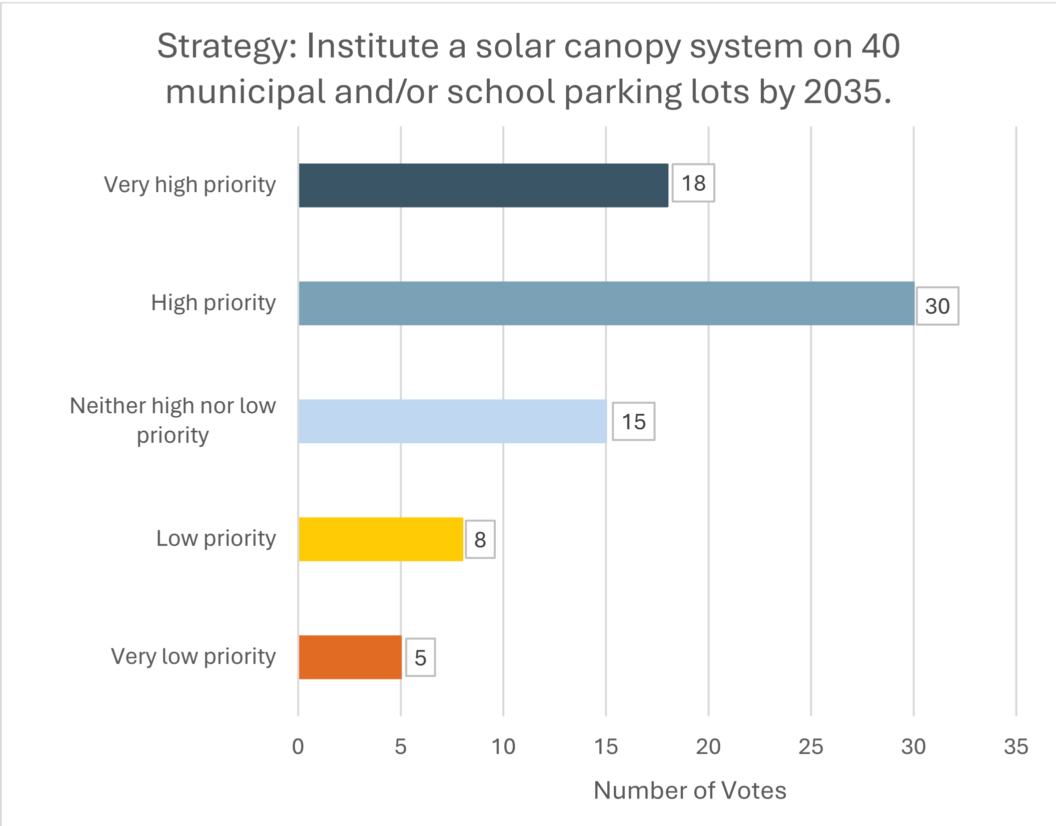
Goal Prioritization Activity

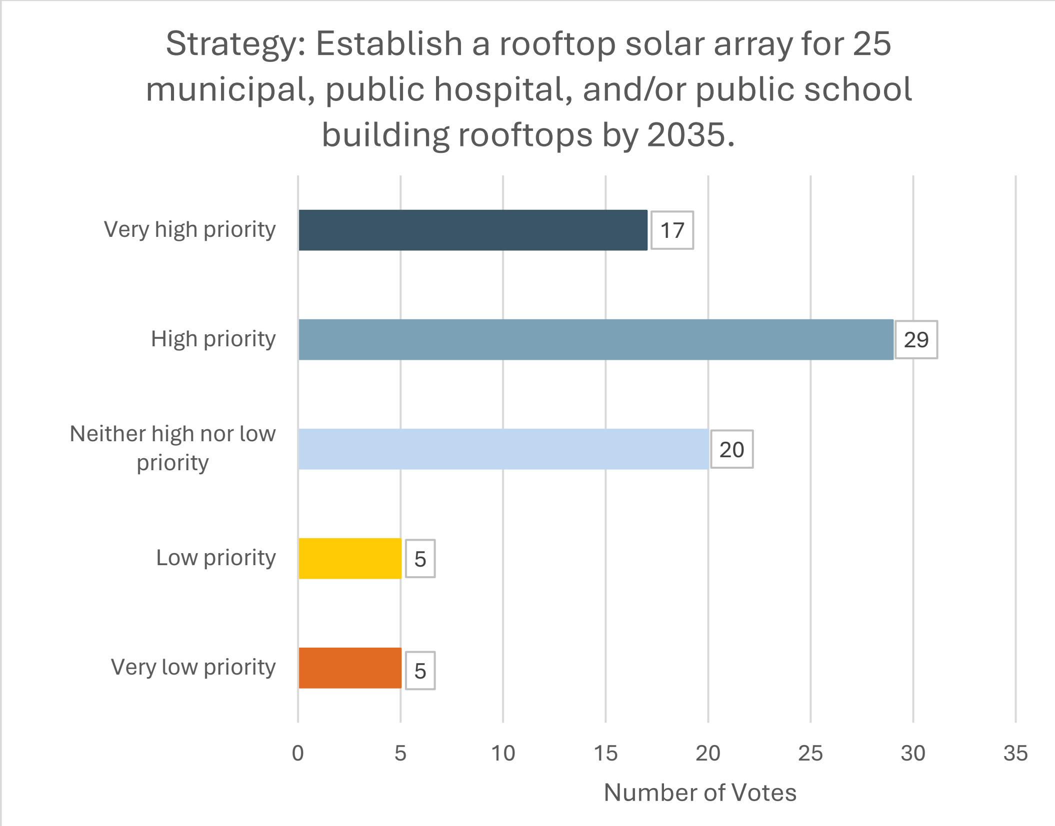
Along with ranking the sectors, workshop attendees were also asked to prioritize the draft goals within each sector. Workshop attendees ranked the four draft goals, with a score of one (1) as highest priority and four (4) as lowest priority. The table below shows the prioritization of the four draft goals based on all the votes from all the community engagement workshops combined. The draft electricity goals are ranked below, from highest priority to lowest priority.

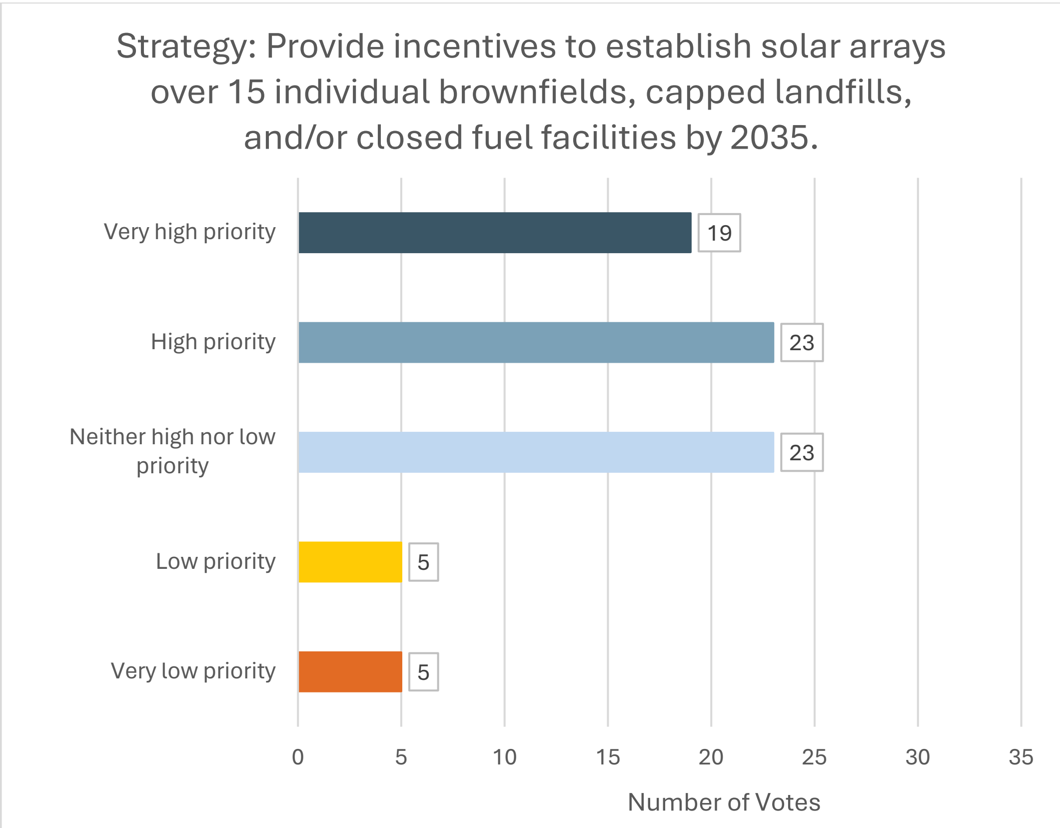
Goal / Option	Rank
Scale up fuel switching efforts that result in less CO2 emissions (i.e., renewable energy generation).	1
Increase the efficiency of and/or decommission existing fossil fuel-fired power plants in the MSA.	2
Reduce overall electricity use and peak demand.	3
Scale up energy transmission infrastructure and electric grid connections.	4

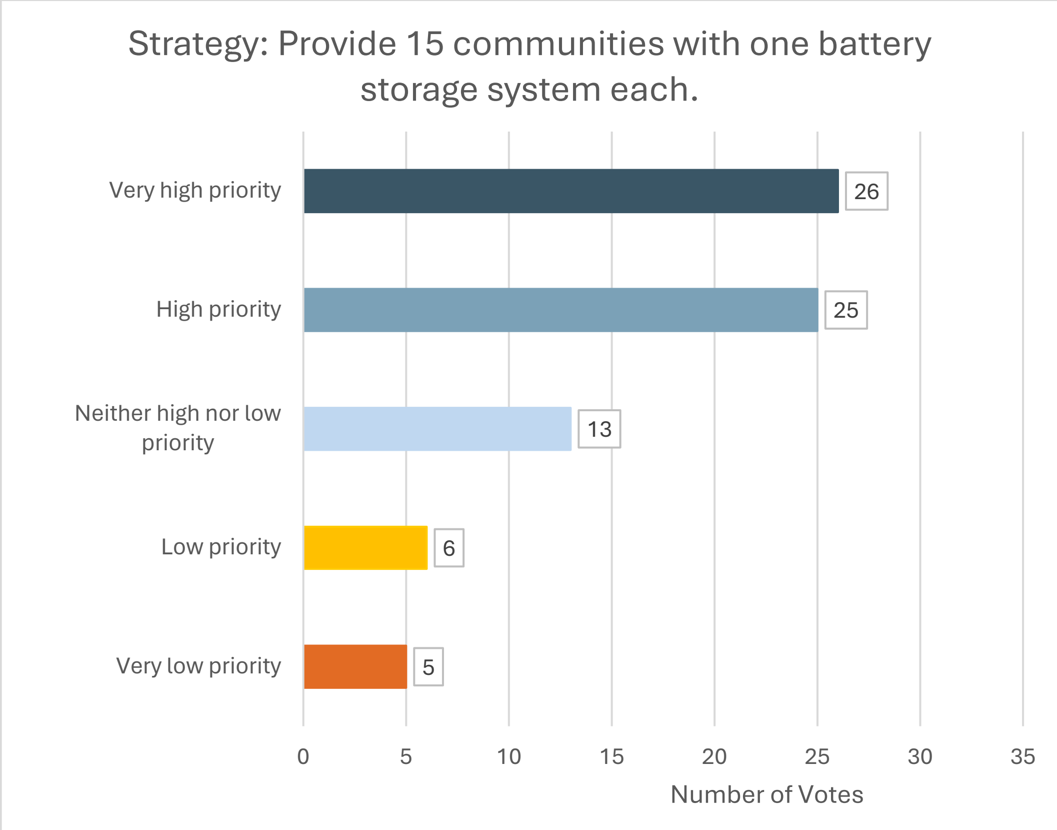
Strategy Prioritization Activity

The results of the section of the public survey in which respondents prioritized the draft climate pollution reduction action strategies for the electricity sector are summarized below. Each action strategy is described in greater detail in the following sections.




Strategy: Establish a rooftop solar array for 25 municipal, public hospital, and/or public school building rooftops by 2035.
Very high priority
17
High priority
29
Neither high nor low priority
20
Low priority
5
Very low priority
5
0
5
10
15
20
25
30
35
Number of Votes


Strategy: Provide incentives to establish solar arrays over 15 individual brownfields, capped landfills, and/or closed fuel facilities by 2035.
Very high priority
19
High priority
23
Neither high nor low priority
23
Low priority
5
Very low priority
5
0
5
10
15
20
25
30
35
Number of Votes



Major Workshop Themes: Electricity Sector

Before completing the goals and formulating action strategies, workshop participants and Regional Planning Agencies discussed their experiences with emissions related to the electricity sector. Community workshop conversations focused on the following major themes concerning the MSA:

1. **The MSA must increase the use of solar energy generation, without clearing forested land.** Increasing solar power generation is one of the most effective and critical ways we can decrease fossil fuel combustion, and therefore reduce human contribution to the Greenhouse Effect. However, across all the workshops, participants emphasized the importance of using solar energy generation without clearing forested land or open space. It was extremely important for participants across each of the workshops to keep forests intact to preserve natural carbon sinks in the MSA. This is why action items in this plan include installation of solar arrays exclusively over land that has already been cleared for other purposes (i.e., canopies over parking lots, rooftop arrays, and systems over capped landfills, brownfields and between highways).
2. **The MSA can simultaneously target capped landfills for both sustainable energy generation and methane capture.** Installing solar on capped landfills and brownfield sites would contribute renewable energy to the grid, therefore lessening demand for energy generated by fossil fuel combustion.

The MSA can combine this effort with capture of methane emitted from decomposing garbage sitting in landfills. This combined approach would be using land in the region that cannot be developed or forested, to reduce and capture Greenhouse Gas emissions simultaneously.

3. **Small, rural, communities with lower population densities need energy justice.** Many participants of the workshops mentioned that the smaller, rural towns regularly face power outages. Because the towns are so small, they can often be overlooked, leaving the causes of common outages unaddressed by the utility.
4. **Municipal Light Plant customers need solar incentives**. Workshop participants across the region discussed that the incentives that make switching to solar possible for many buildings and homeowners are utility-based incentives. This leaves residents and building owners in Municipal Light Plants unable to receive help from such financial incentives for solar.
5. **To increase use of renewable energy sources, the MSA must improve energy storage.** Storage is essential to perfect energy from renewable sources because the nature of renewable energy generation is intermittent. Solar panels will generate much more energy during the day, during sunny days, and during days with more sunlight (i.e., summer season). With an increase in solar energy generation, storage systems are needed to balance energy demand with this intermittent supply.

Electricity Sector: Goals, Strategies and Actions

Goals

During the community engagement workshops, participants provided feedback and edits for each of the goals. The following are the finalized goals for the electricity sector:

Goal 1: Scale up fuel switching efforts that result in less CO2 emissions (i.e., renewable energy generation). - **CRITICAL IMPORTANCE**

Goal 2: Increase the efficiency of and/or decommission existing fossil fuel-fired power plants in the MSA. - **VERY IMPORTANT**

Goal 3: Reduce overall electricity use and peak demand. - **VERY IMPORTANT**

Goal 4: Scale up energy transmission infrastructure and electric grid connections. - **VERY IMPORTANT**

Strategies and Actions

Finally, action strategies were distilled from the major themes of workshop discussion and ranking of the emissions reduction goals. For this sector, CMRPC also met with ISO New England and the state of Massachusetts Department of Energy Resources (DOER) to ensure the following action strategies align with the goals of both agencies. CMRPC and the DOER acknowledged the following strategies align with the goals of pre-existing DOER programs, such as the Solar Massachusetts Renewable Target (SMART)[cxci] and Solar For All programs in Massachusetts.[cxcii] In addition, CMRPC spoke with the MA DOER about utilizing their new Solar Siting Tool[cxciii] online when examining implementation grant application opportunities for the following strategies under the electricity sector.

The following table shows the strategies, their corresponding goals, emissions reductions, LIDAC benefits, and more. Workshop participants voted to prioritize the following strategies, and Weston and Sampson quantified the emissions reductions for each measure.

Table 19: Priority Electricity Sector Strategies

Goal#	Strategy	Public Priority	kWh Reduced	Estimated GHG Reduction (MTCO2e/year)	Muni. Cost Savings ($)	Approx. Costs ($)	LIDAC Benefits	Authority to Implement
1, 2	Institute a solar canopy system on 40 municipal and/or school parking lots by 2035.	High	43,000,000	9,525	High	High	Medium	Local, regional
1, 2	Establish a rooftop solar array for 25 municipal, public hospital, and/or public school building rooftops by 2035.	High	41,000,000	9,082	High	High	High	Local, regional
1, 2	Provide incentives to establish solar arrays over 15 individual brownfields, capped landfills, and/or closed fuel facilities by 2035.	High/Med.	93,000,000	20,601	High	High	High	Local, regional, private and public
4	Provide 15 communities with one battery storage system each.	High/ Very High	2,880,000	627	High	High	Medium	Local, regional

Action Strategy Narratives and LIDAC Analysis

Strategy 1: Institute a solar canopy system on 40 municipal and/or school parking lots by 2035.

Overview

This strategy includes instituting a solar canopy system on 40 municipal and/or school parking lots by 2035, with priority given to lots in low-income disadvantaged communities. Solar canopies are structures with solar panels on the top that are built over parking lots. Small or rural communities with frequent power outage issues and communities served by Municipal Light Plants will also receive priority.

Emissions Reduction Contribution

To quantify this measure, Weston and Sampson used the MA Technical Potential of Solar mapping tool. The estimated average municipal and school parking lots were identified as 654 kW. Based on EPA AVERT and 2017 emissions factors, Weston and Sampson concluded that an approximated 43,000,000 kWh would be avoided by installing this measure. This would result in emissions reduction of 9,525 MTCO2e per year in the year 2035.

Benefits and Challenges

Solar canopies will bring a few challenges, but a greater number of benefits to a community. First, a challenge associated with this strategy is the high price of the steel needed for solar canopies currently. In addition, installing solar canopies over parking lots will require a lot of technological investment in that lot, meaning it would be much more difficult to convert that lot into another use in the future.

Despite these challenges, there are many benefits to this action item. First, the canopies will be found over pre-existing paved parking lots, avoiding the clearing needed for a solar field. This allows communities to preserve open space, therefore protecting natural carbon sinks, mitigating stormwater absorption, and preserving rural aesthetics and natural beauty. The power generated by solar systems over parking lots can be used onsite by nearby buildings associated with the parking lots. This renewable energy source will be used to power associated buildings or streetlights, reducing load demand for electricity generated with fossil fuels from the former associated power plant. Priority for incentives for solar canopies will be given to designated low-income disadvantaged populations, therefore lowering energy bills for systemically over-burdened folks.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Improved energy resilience
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence
	Workforce development

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Authority to Implement

Results of community engagement workshops noted this strategy as a high priority for this plan. Local and regional entities have a high authority to implement this strategy, specifically the municipalities and schools owning the parking lots involved. The IRA funding will be used for the cost of the solar installation, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work.

Strategy 2: Establish a rooftop solar array for 25 municipal, public hospital, and/or public school building rooftops by 2035.

Overview

This project will distribute funding for rooftop solar on municipal, public hospital, or public school rooftops through need-based incentives. Buildings in low-income disadvantaged communities will be eligible for the highest funding for roof-top solar installation. Small or rural communities with frequent power outage issues and communities served by Municipal Light Plants will also receive priority. Roof replacement and construction to prepare for rooftop solar will be accounted for.

Emissions Reduction Contribution

To quantify this measure, Weston and Sampson used the MA Technical Potential of Solar mapping tool. The estimated average municipal, school, and hospital rooftops were found to have a capacity of 502 kW. Based on EPA AVERT and 2017 emissions factors, Weston and Sampson concluded that an approximated 41,000,000 kWh would be avoided by installing this measure. This would result in emissions reduction of 9,082 MTCO2e per year in the year 2035.

Benefits and Challenges

Rooftop solar for these entities will bring a few challenges, but a greater number of benefits to a community. First, a challenge associated with this strategy is repairing roofs that are currently outdated and not equipped to support solar installations. Also, rooftop solar damage from hot spots, or wildlife will also need to be repaired which can be costly. Despite these challenges, there are many benefits to this action strategy. First, these solar systems will be installed on building rooftops, therefore using preexisting roof-space and not involving any forest clearing for solar panels. This allows communities to preserve open space, therefore protecting natural carbon sinks, mitigating stormwater absorption, and preserving rural aesthetics and natural beauty. In addition, the power generated by solar systems over parking lots can be used onsite by the building. This renewable energy source used to power the building will reduce load demand for electricity generated with fossil fuels from the former associated power plant. This will also lower the electricity bills for the associated municipal, school, or hospital building.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Improved energy resilience
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence
	Workforce development

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income, unemployment, and elevated flood risk.

Overall Priority and Authority to Implement

Results of community engagement workshops noted rooftop solar for municipal, hospital, and school buildings as high priority for this plan. Local and regional entities have a high authority to implement this strategy, specifically the municipalities and schools owning the buildings involved. The IRA funding will be used for the cost of the solar installation, roof replacement/upgrades, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work.

Strategy 3: Provide incentives to establish solar arrays over 15 individual Brownfields, capped landfills, and/or closed fuel facilities by 2035.

Overview

This strategy is to establish a solar array over the top of 15 brownfields, capped landfills, and/or closed fuel facilities across the MSA by 2035. Designated low-income disadvantaged communities with brownfields, capped landfills and/or closed fuel facilities will receive the largest financial incentives for these systems. Small or rural communities with frequent power outage issues and communities served by Municipal Light Plants will also receive priority. CMRPC has discussed this action with the Independent System Operator (ISO) for New England. If the MSA moved forward with this action, the solar arrays over brownfields/capped landfills/closed fuel facilities could be grid-connected. ISO New England has let CMRPC know they are planning for an influx of energy generation from solar pouring into the electrical grid supply.

Emissions Reduction Contribution

To quantify this measure, Weston and Sampson used the MA Technical Potential of Solar mapping tool. The estimated average brownfield and landfill sites were found to have a capacity of 56,149 kW. Based on EPA AVERT and 2017 emissions factors, Weston and Sampson concluded that an approximated 93,000,000 kWh would be avoided by installing this measure. This would result in emissions reduction of 20,601 MTCO2e per year in the year 2035.

Benefits and Challenges

A solar field installed over a brownfield, landfill, or decommissioned power plant will bring a few challenges, but a greater number of benefits to a community. First, a challenge associated with this strategy is the fact the landfills are not initially designed for traffic or to bear heavy structures. Therefore, the cap design over a landfill must include added measures to prepare for solar. This may include a 6-12 inch thick subgrade of rock, a geocomposite drainage net, flexible membrane layer, geosynthetic clay layer, and a couple of feet of soil with a vegetative layer to support grass growth.[cxciv]

Despite these challenges, there are many benefits to this action strategy. First, this solar system will be installed on decommissioned space that has already been cleared and cannot be used for many other purposes. Therefore, this measure does not involve forest clearing for solar panels. This allows communities to preserve open space, therefore protecting natural carbon sinks, mitigating stormwater absorption, and preserving rural aesthetics and natural beauty. In addition, to use the capped landfill space for solar, the owner must get the space properly registered as closed with the proper regulatory agency. This will serve as an incentive to ensure the landfill is closed and capped properly. In addition, methane capture could also be implemented simultaneously to this measure, increasing the space's reduction potential.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Improved energy resilience
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence
	Workforce development

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income, unemployment, legacy pollution and elevated flood risk.

Overall Priority and Authority to Implement

Results of community engagement workshops noted solar installation over brownfields and capped landfills as tied for high priority, or neither high nor low priority (both categories receiving 23 votes) for this plan. Both private owners and local and regional entities have a high authority to implement this strategy, depending on which party owns the lot or field in question. Capped landfills will be officially registered as "closed" (or similar proper designation) with local or state regulatory system to take part. The IRA funding will be used for the cost of the solar installation, technical assistance, public/other stakeholder engagement work, project management, grant administration, and site management work.

Strategy 4: Provide 15 communities with one battery storage system each.

Overview

Battery Storage Systems store electricity generated by renewable energy. CMRPC will work with ISO New England to decide which 15 locations across the MSA would be most beneficial to function as sites for storage, providing optimized renewable energy storage for the entire MSA.

Emissions Reduction Contribution

To quantify this measure, Weston and Sampson assumed the measure would use 1 MW storage systems with average target discharge duration and cycles per year. They also assumed that all energy would be used, avoiding use of grid electricity. Weston and Sampson noted that systems with larger capacity will have higher associated emissions reductions. This would result in emissions reduction of 627 MTCO2e per year in the year

2035. Weston and Sampson noted that more information about the Massachusetts Storage Initiative is available here: MA Storage Initiative Information.[cxcv]

Benefits and Challenges

Added battery storage systems will bring a few challenges, but a greater number of benefits to a community. First, a challenge associated with this strategy is the price of the system. Battery storage is still costly in the current market. Also, battery storage systems are often large, creating an aesthetic or spatial barrier for some communities.

Despite these challenges, there are many benefits to this action strategy. First, the batteries will increase the reliability and functionality of all solar energy generation from each other action strategies under this sector. Long term, renewable energy batteries lower energy bills, require minimal maintenance, and have a long lifespan. Also, battery storage provides energy independence through power back up during outages.[cxcvi] This could be particularly beneficial for parts of the MSA that struggle with frequent outages, especially small or rural towns.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Improved energy resilience
Community vulnerability to climate change impacts is reduced	Reduced energy consumption and associated costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income and elevated flood risk.

Overall Priority and Authority to Implement

Results of community engagement workshops noted supplying communities with battery storage systems as a very high priority for this plan. Local and regional entities have a high authority to implement this strategy, depending on which party will own the battery. The IRA funding will be used for the cost of the battery, technical assistance, public/other stakeholder engagement work, project management, grant administration, and site management work.

Residential & Commercial Buildings

Commercial and Residential Buildings

Connecticut and Massachusetts commercial and residential buildings span a wide range of ages, types, and uses. The costs and emissions associated with powering, heating or cooling these buildings depend directly on these factors and many others, such as weatherization. The more weatherized and energy efficient residential and commercial buildings are, the less energy is needed to heat and cool them throughout the year. Natural gas and petroleum products (oil and propane) heat most buildings in Massachusetts and Connecticut. Both fuel sources emit greenhouse gases, with emissions associated with residential building fuel oil consumption nearly double that of natural gas consumption. [cxcvii] As the region considers how to increase efficiency and decrease emissions associated with our buildings, continuing to move away from fossil fuels is critical.

How does the Buildings Sector contribute to climate pollution emissions?

Residential, commercial, industrial, and government/school buildings contribute both indirectly and directly to climate pollution. First, buildings indirectly contribute to climate pollution because buildings are powered by electricity. As discussed above, power plants that use fossil fuels, such as natural gas, are producing electricity to send to buildings. Therefore, how much electricity a building demands shows how much electricity the associated power plant needs to supply. Because buildings, and the people in them, dictate the amount of electricity needed from thermal power plants each day, buildings are the leading factor deciding the quantity of fossil fuels that need to be burned with these plants. Therefore, the amount of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, polluted into the air will be indirectly influenced by the way people use energy in buildings.[cxcviii]

Along with deciding the impact electrical power plants have on the environment, each building also has direct emissions associated with heating and other fossil fuel combustion-based processes that are contributing to climate pollution. Many buildings do not use electricity for heating, cooling, and cooking. Rather, many individual buildings use fossil fuels, such as natural gas, for space heat, stoves, or boilers, and fuel oil for heat.[cxcix] While each building's fossil fuel use is smaller than an electrical power plant, there are far more residential, commercial, industrial, and government/school buildings across the MSA than there are power plants. This shows that the cumulative impact of using fossil fuels across all types of buildings will contribute massive amounts of carbon dioxide, methane, and other greenhouse gas emissions, worsening climate pollution.

Building Emissions Contribution

For the GWPCAP's GHG inventory, the emissions associated with the Region's Stationary Energy and Electricity Sector are split into three subsectors: residential buildings; commercial, institutional buildings, and manufacturing industries;

construction. This section of the GWPCAP focuses on the all the GHG emissions associated with commercial and residential buildings in the region. Emissions from buildings stem from various sources, including electricity, fuel oil, and natural gas. Overall, the region's stationary energy sector contributed 3.4 million metric tons of carbon dioxide equivalent emissions (MMT CO2e) into the atmosphere in 2017, with the residential buildings subsector contributing 2.23 MMT CO2e and the commercial, institutional, and industrial buildings subsector contributing 2.54 MMT CO2e. The Region's stationary energy sector is the second largest emitter of GHGs, contributing 31% of the Region's total in 2017.[cc]

Table 20: Building Emissions by Source and Subsector

Subsector	Source	Carbon Dioxide Equivalent Emissions (MTCO2e)	% of Total Energy Emissions
Residential Buildings	Res. Electricity	610,015	5.5%
	Res. Fuel Oil	983,991	8.9%
	Res. Natural Gas	640,961	5.8%
Commercial & Institutional Buildings and Facilities + Manufacturing Industries*	Comm. & Man. Electricity	883,950	8.0%
	Comm. & Man. Fuel Oil	249,908	2.3%
	Comm. & Man. Natural Gas	1,214,107	11.0%
All Buildings	Electricity	1,493,965	13.5%
	Fuel Oil	1,233,899	11.2%
	Natural Gas	1,855,068	16.8%

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cci]

Regional Context

Massachusetts

According to the Massachusetts Climate Report Card, the Buildings sector contributes 35% of the entire Commonwealth's Greenhouse Gas emissions.[ccii] Buildings are divided into use classes, including single family residential, small multifamily, large multifamily, office, retail, supermarket, convention/assembly, school, hospital, laboratory, hotel, restaurant, warehouse, and industrial.[cciii] The key is to switch buildings across all use classes to be powered by electricity for everything that requires power. Buildings need to be expanded beyond powering their lights with electricity and electrify their heat, cooling, ventilation, water heating, stoves, ovens, and more. Luckily, Massachusetts is a national leader in electrification of buildings. In February of 2024, Massachusetts and a group of nine other US states released an agreement. The ten states are aiming for 65% of new residential heating, ventilation, cooling, and water heating to be electrified using heat pumps by 2030, and 90% by 2040.[cciv] With ambitious goals set, the state of Massachusetts is working to reduce the carbon footprint of buildings state-wide.

Connecticut

Similarly, Connecticut's buildings emit a large amount of the state's total greenhouse gas inventory. Like Massachusetts, a substantial part of Connecticut's buildings are heated with natural gas (36%). However, unlike Massachusetts, an even larger 42% of residential buildings in Connecticut are heated with oil or other petroleum products. This near-half percent of households shows that Connecticut has the fourth highest number of households still heated with oil out of the United States.[ccv] Due to heavy reliance on combustion of fossil fuels for HVAC and water heating within buildings, the buildings sector alone accounts for over 25% of all the State of Connecticut's Greenhouse Gas emissions.[ccvi] This number does not include the indirect fossil fuel emissions associated with building electricity use. Therefore, with the addition of emissions associated with generation of electricity, Connecticut produces more greenhouse gases into the atmosphere, worsening climate pollution.

Worcester, MA-CT MSA

Weston and Sampson created a snapshot of data for how the buildings in the Worcester MA-CT Metropolitan Statistical Area emit greenhouse gases.

Table 21: Emissions by Subsector

Subsector	Source	Carbon Dioxide Equivalent Emissions (MT CO2e)	Percent of Total
Residential Buildings	Electricity	581,109.23	5%
	Electricity T&D Losses	28,905.72	0%
	Fuel Oil	983,990.77	9%
	Natural Gas	504,253.72	5%
	Nat. Gas. Dist. Losses	136,707.40	1%
Commercial & Institutional Buildings & Manufacturing Industries	Electricity	841,437.47	8%
	Electricity T&D Losses	42,512.80	0%
	Fuel Oil	249,908.49	2%
	Natural Gas	955,156.22	9%
	Nat. Gas. Dist. Losses	258,950.83	2%

	Off-Road (Various Fuels)	189,033.75	2%
Construction	Off-Road (Various Fuels)	157,813.37	1%

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[ccvii]

Because its related emissions are higher than natural gas, Weston and Sampson also highlighted the emissions from fuel oil used in the MSA to heat homes.

Table 22: Fuel Oil Building Use

Subsector	Annual Fuel Oil Use (gal)	Annual Fuel Oil Use (MMBtu)	Fuel Oil CO2e Emissions (MT CO2e)
Residential Buildings	96,092,716.79	13,260,794.92	983,990.77
Commercial & Institutional Buildings	20,782,172.13	2,867,939.75	212,809.73
Manufacturing Industries & Construction	1,624,177.36	224,136.48	16,631.60
Municipal Buildings	2,005,141.39	276,709.51	20,467.15
All Building Subsectors:	**120,504,207.67**	**16,629,580.66**	**1,233,899.25**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[ccviii]

The emissions inventory tables above show buildings are responsible for large amount of atmospheric greenhouse gases from the Worcester MA-CT MSA. The goals and action strategies featured in the rest of this section try to utilize energy efficiency and electrification to reduce greenhouse gas emissions associated with the buildings sector in the MSA.

Community Engagement Workshops: Buildings Sector Results

Sector Prioritization Activity

Participants in each of the workshops hosted across the MSA were given the opportunity to vote for the top two sectors they viewed as their first priorities for climate emissions mitigation. Results of all the workshops showed that the Buildings Sector ranked the fifth highest priority.

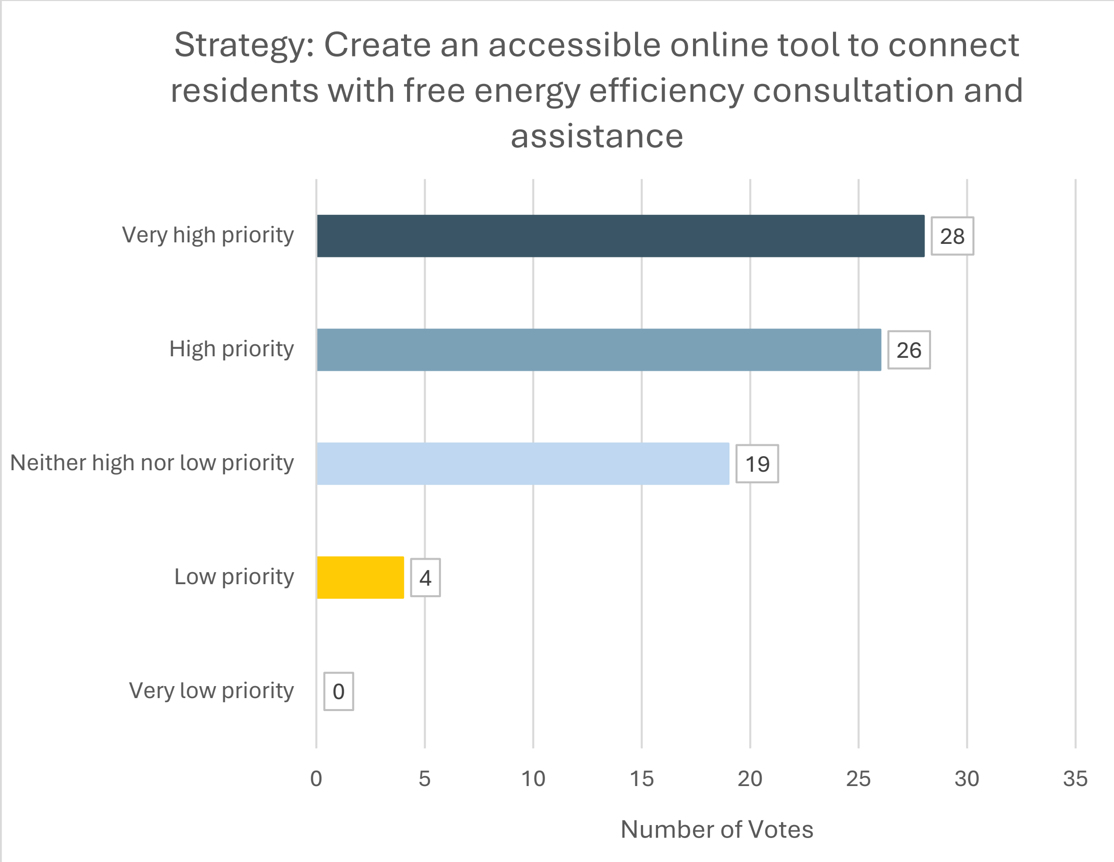
Goal Prioritization Activity

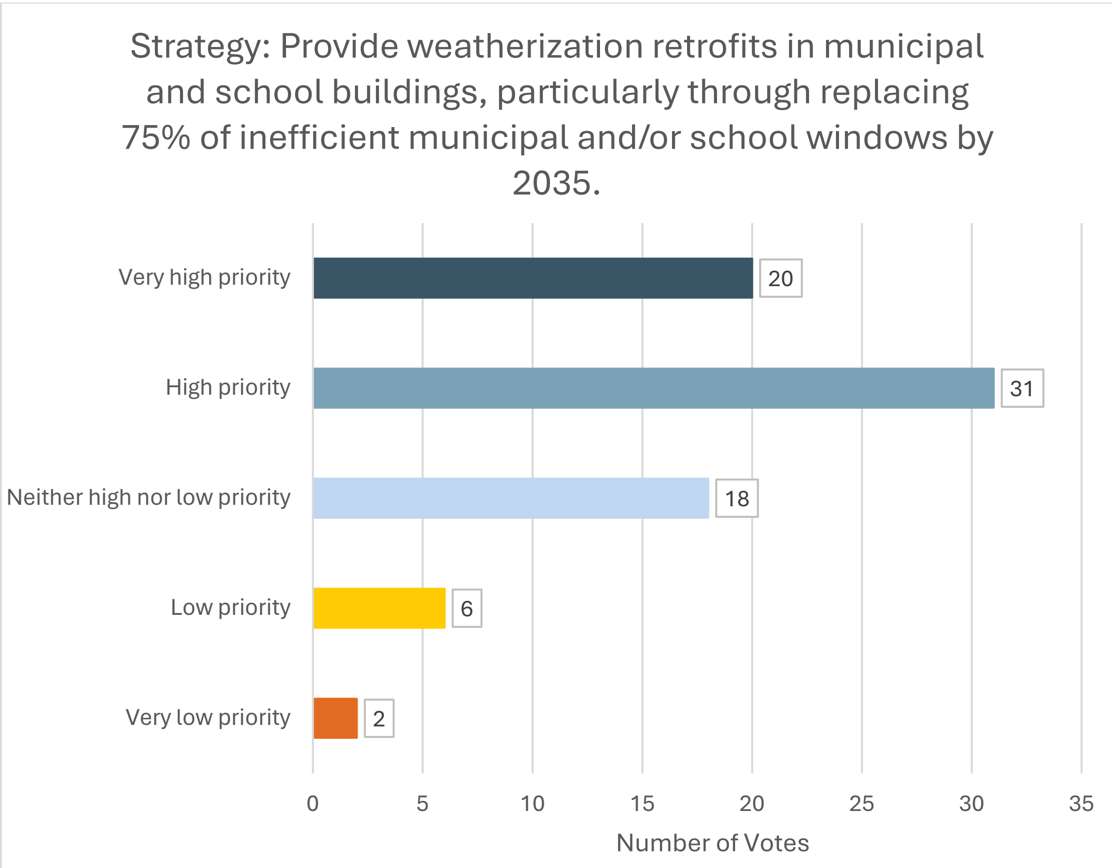
Along with ranking the sectors, workshop attendees were also asked to prioritize the draft goals within each sector. Workshop participants ranked the four draft goals, with a score of one (1) as highest priority and four (4) as lowest priority. The table below shows the prioritization of the four draft goals based on all the votes from all the community engagement workshops combined. The draft buildings sector goals are ranked below, from highest priority to lowest priority.

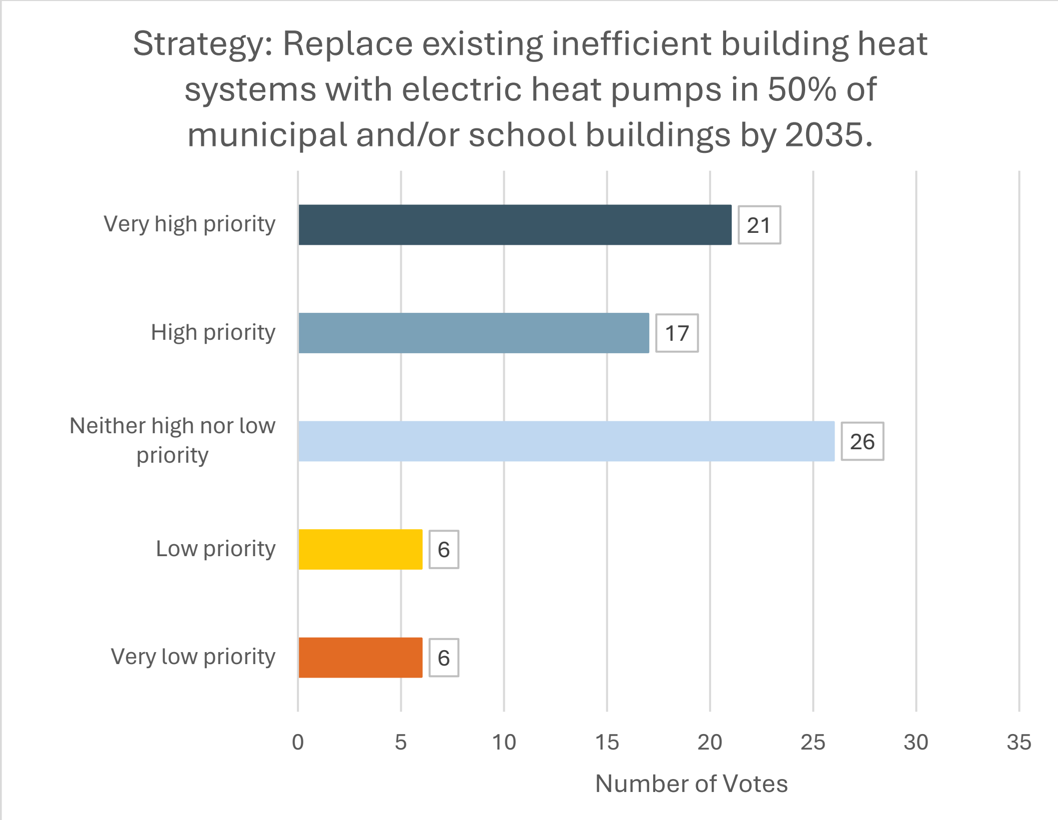
Goal / Option	Rank
Reduce energy use via enhanced energy efficiency measures (weatherization measures, air conditioning, and refrigeration equipment)	1
Power commercial and residential buildings with renewably sourced electricity (i.e., building lighting, HVAC, heating & cooling)	2
Promote passive heating and cooling measures through building design	3
Improve energy efficiency of drinking water and wastewater management facilities	4

Strategy Prioritization Activity

The results of the section of the public survey in which respondents prioritized the draft climate pollution reduction action strategies for the residential and commercial buildings sector are summarized below.


Strategy: Create an accessible online tool to connect residents with free energy efficiency consultation and assistance
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
28
26
19
4
0
0
5
10
15
20
25
30
35
Number of Votes


Strategy: Provide weatherization retrofits in municipal and school buildings, particularly through replacing 75% of inefficient municipal and/or school windows by 2035.
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
20
31
18
6
2
0
5
10
15
20
25
30
35
Number of Votes



Major Workshop Themes: Buildings Sector

Community engagement across the MSA revealed the following major themes for the buildings sector:

1. **Retrofitting older housing stock must be considered.** Many workshop participants noted that a substantial part of the housing stock in many parts of the MSA has already been built and was built before a more stringent building code for energy efficiency was enacted. Therefore, measures under the building sector in this plan were designed to consider improving energy efficiency in old buildings.
2. **Renters must be given the tools to improve residential energy efficiency.** Tailoring home energy efficiency to the homeowner leaves a substantial proportion of the MSA's residents unable to receive help from these improvements. Ownership of a home should not and cannot be a requirement for increasing the energy efficiency of residential buildings in this plan. Measures in this plan should consider the types of resources renters will need to work with landlords and homeowners' associations to receive help from these climate actions.
3. **New, stringent guidelines for zoning and construction reform should be shaping the future of buildings in the MSA.** Along with retrofitting older buildings, participants of the community engagement workshops also echoed the need to pave the way for energy efficiency in newly constructed buildings.

Participants discussed the need to require energy efficient measures and technology in newly constructed buildings through zoning, construction, and building code reform. These stringent requirements must be adopted across the MSA to ensure new buildings are responsible for the lowest number of emissions possible.

4. **Electric heat pumps and electric stoves are needed to reduce direct greenhouse gas emissions from all types of buildings.** Workshop participants discussed the need to remove fossil fuel combustion from residential, commercial, and municipal/school buildings across the MSA. When accumulated together, fossil fuel-fired boilers, heaters, stoves, and other building appliances across the millions of buildings in the MSA are a leading source of emissions. If these appliances were replaced with electric sources (such as electric heat pumps, stoves, electric boilers, etc.) buildings themselves would no longer be emitting greenhouse gases directly into the atmosphere.
5. **Building occupants need to learn how to improve energy efficiency through educational campaigns.** Participants of the workshops described the need to teach residents how to live, work, or generally utilize buildings in an energy efficient manner. Community members across the MSA agreed that behavioral practices to conserve energy need to be addressed, such as turning off lights and appliances when they are not in use and understanding the transition from natural gas stoves and space heat to electric stoves and heat pumps.

Buildings Sector: Goals, Strategies and Actions

Goals

During the community engagement workshops, participants provided feedback and edits for each of the goals. The following are the finalized goals for the electricity sector:

Goal 1: Power residential, commercial, and municipal buildings with exclusively electricity (i.e., electric heat pumps, electric water heaters, etc.). - **IMPORTANT**

Goal 2: Reduce energy use in residential, commercial, and municipal buildings via enhanced energy efficiency measures (i.e., weatherization measures, air conditioning, and refrigeration equipment.) - **IMPORTANT**

Goal 3: Improve energy efficiency of drinking water, wastewater, and waste management buildings. - **NOT AS IMPORTANT**

Goal 4: Promote passive heating and cooling measures through building design. - **NOT AS IMPORTANT**

Table 23: Buildings Sector Priority Strategies

Goal #	Strategy	Public Priority	Estimated GHG Reductions (MTCO2e/ year	Muni. Cost Savings ($)	Approx. Costs ($)	LIDAC Benefits	Authority to Implement
1, 2	Create an accessible online tool to connect residents with free, comprehensive consultation for how to make their homes energy efficient. This program's goal will be to provide weatherization retrofits for 50% of the MSA's housing stock 2035. Priority will be given to older buildings, particularly homes built before standard building codes were enacted.	Very High	143,449	High	Low	High	Local, regional
1, 2, 3	Provide weatherization retrofits in municipal and school buildings, particularly through replacing 75% of inefficient municipal and/or school windows by 2035.	High	4,846	Medium	Med.	Medium	Local, regional
1, 2, 3	Replace existing inefficient building heat systems with electric heat pumps in 50% of municipal and/or school buildings by 2035.	Med.	35,824	High	High	Medium	Local, regional

Strategy Narratives

Strategy 1: Create an accessible online tool to connect residents with free, comprehensive consultation for how to make their homes energy efficient. This program's goal will be to provide weatherization retrofits for 50% of the MSA's housing stock by 2035. Additional resources for renters and owners of older buildings (built before standard building codes were enacted) will be included.

Overview

This measure would allow the Regional Planning Agencies in the MSA to create a cohesive online Program Finder to effectively use the many home energy efficiency programs that are currently offered across utility providers, and pair them up with a free home energy efficiency consultant to aid them in the process. Residents would be able to enter basic information about how they might be looking to make their homes energy efficient, and what kind of home in which they live. This Program Finder will have added guidance for residents of Municipal Light Plants (MLPs), renters, and residents with older homes (built before more stringent building codes were enacted). Upon completion of this online Program Finder, the resident will relate to a free consultant to lead them through the process moving forward.

Emissions Reduction Contribution

To quantify the emissions reductions for this measure, Weston and Sampson assumed a reduction of 15% of energy use from increased weatherization of housing. They then quantified a 15% reduction in energy use for 50% of the MSA's housing stock. This measure equated to saving 178,722,636 kWh of electricity, 7,129,301 therms of natural gas, and 836,961 MMBTU of fuel oil. The total emissions reduction for this measure was quantified at 143,449 MTCO2e per year in the year 2035.

Benefits and Challenges

This measure will bring a few challenges, but a greater number of benefits to a community. First, a challenge associated with this strategy will be ensuring populations that are overburdened by systemic injustices are able to utilize the tool and consultation services. To account for this, CMRPC and the other RPAs within the Worcester MA-CT MSA will ensure extra outreach about the program will be conducted, including multiple language translation, attendance at community events, and other forms of outreach.

Despite these challenges, there are many benefits to this action strategy. This Program Finder will aid residents in the MSA to properly use the many home energy efficiency programs that are currently offered across utility providers (such as the Low-Income Energy Affordability Network Multifamily Program[ccix] and the MA Weatherization Assistance Program[ccx]) but often not used because residents do not know where to start or how to navigate the process. This online program and consultant aid service will be designed to aid everyone, with added services and resources that focus primarily on comprehensive weatherization retrofits for existing housing stock built before stringent building code was enacted. Weatherization measures may include installation of increased building insulation, sealing the building envelope from energy leaks, and more. These measures are key to reducing energy waste related to heating, ventilation, and air conditioning (HVAC) and decreasing the amount of energy a building needs to use to remain at a comfortable temperature.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Reduced energy consumption and associated costs
Community vulnerability to climate change impacts is reduced	Decreased morbidity incidence
Risk of climate change impact is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Workforce development
	Reduced maintenance needed for heating and cooling of buildings

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income and elevated flood risk.

Overall Priority and Authority to Implement

Results from the community engagement workshops and associated quantified greenhouse gas reductions noted this strategy as a very high priority. Local and regional entities have a high authority to create this online tool and consultation service. The IRA funding will be used for the cost of the work associated with creating this service, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work.

Strategy 2: Provide weatherization retrofits in municipal and school buildings, particularly through replacing 75% of inefficient municipal and/or school windows by 2035.

Overview

This measure will implement weatherization retrofits for municipal and school buildings in the MSA. Weatherization measures may include installation of increased building insulation, sealing the building envelope from energy leaks, and more. Prioritization given to implementation of new, weatherized windows in municipal and/or school buildings built before stringent building codes were enacted. In addition, priority will be given to school and municipal buildings in low income and disadvantaged communities.

Emissions Reduction Contribution

To quantify the emissions reductions for this measure, Weston and Sampson used the Department of Energy's determination that windows are responsible for 8.6% of building energy use. They assumed new windows are twice as efficient as older windows. Weston and Sampson concluded that this measure would reduce emissions by 4,846 MTCO2e per year in the year 2035.

Benefits and Challenges

Weatherization and weatherized windows for these entities will bring a few challenges, but a greater number of benefits to a community. For example, one challenge is that weatherization must occur when school is not in session, so the expeditors can have full uninterrupted access to the building. However, there are many benefits to this action strategy. This measure is key to reducing energy waste related to heating, ventilation, and air conditioning (HVAC) and decreasing the amount of energy a building needs to use to remain at a comfortable temperature. Without feeling drafty or too hot during the year, students in school and municipal employees may be able to improve productivity. Another benefit to increased weatherization and weatherized windows in these buildings is reduced energy consumption and cost for school and municipal buildings.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Reduced energy consumption and associated costs
Community vulnerability to climate change impacts is reduced	Reduced healthcare costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Decreased morbidity incidence
Reduced air pollution (i.e., PM2.5)	Reduced maintenance needed for heating and cooling of buildings

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income and elevated flood risk.

Overall Priority and Authority to Implement

Results of community engagement workshops noted weatherization measures for municipal and school buildings as high priority for this plan. Local and regional entities have a high authority to implement this strategy, specifically the municipalities and schools owning the buildings involved. The IRA funding will be used for the cost of the weatherization installation, building envelope upgrades, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work.

Strategy 3: Replace existing inefficient building heat systems with electric heat pumps in 50% of municipal and/or school buildings by 2035.

Overview

This measure will offer the replacement of old, inefficient heating systems in municipal and/or school buildings with electric heat pump installation. This strategy will include weatherization measures needed before installing the heat pump into the space(s).

Emissions Reduction Contribution

Weston and Sampson concluded that if by the year 2035, half (50%) of municipal and/or school buildings transitioned to heat from electric heat pumps, the buildings would see a 50% reduction in natural gas and oil usage. They assumed that no added emissions would be associated with the increase in electricity usage, because electricity would be harnessed from renewable sources. Weston and Sampson concluded that this measure would show a reduction of 35,824 MTCO2e per year.

Benefits and Challenges

Installing heat pumps for these buildings will bring a few challenges, but a greater number of benefits to communities. For example, one challenge is that heat pumps require the building they are going into to be weatherized to sustain energy efficiency. For this measure, each building in which a heat pump is installed will also have to be weatherized to a proper degree.

There are many benefits to this action strategy. This measure is key to reducing greenhouse gas emissions related to building heating and cooling, as well as decreasing the amount of energy a building needs to use to remain at a comfortable temperature. Electric heat pump systems can be used to both heat and cool buildings and are more efficient than fossil fuel-utilizing heating fixtures. This will allow the municipality or school to save on energy costs while keeping the building at a comfortable temperature through the year. Along with being more efficient, heat pumps are fueled with electricity, therefore they do not need natural gas or other fossil fuels to heat, cool, or ventilate a space. By removing fossil fuel combustion from municipal and school buildings, and increasing electricity use, this measure will decrease climate pollution within the building sector.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities

Direct Benefits	*Co-benefits*
Reduced greenhouse gas emissions	Reduced energy consumption and associated costs
Community vulnerability to climate change impacts is reduced	Reduced healthcare costs
Risk of climate change impact is reduced (i.e., heat, flooding)	Decreased morbidity incidence
Reduced air pollution (i.e., PM2.5)	Reduced maintenance needed for heating and cooling of buildings

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, energy burden, low-income and elevated flood risk

Overall Priority and Authority to Implement

Based on the community engagement feedback and the quantified greenhouse gas reductions associated with this action, replacing heating and cooling systems in municipal/school buildings is ranked as high priority for this plan. Local and regional entities have a high authority to implement this strategy, specifically the municipalities owning the buildings involved. The IRA funding will be used for the cost of the heat pumps, installation by a vendor, technical assistance, public/other stakeholder engagement work, project management, grant administration, and procurement management work.

Waste Management

Waste Management

Overall, the waste management sector produces climate pollution emissions at all areas of the waste management process, including the manufacturing, transportation, processing, incineration, and landfilling of waste. Common pollutants that are produced from this sector include methane, nitrous oxide (NOx), particulate matter, fly ash, carbon monoxide (CO), heavy metals, dioxins, and PFAS - all of which help to contribute to the pollution of air and waterways across the country.

The reuse, recovery, and sustainable management of waste are all associated with better cost savings, as well as positive public and environmental health benefits outside of the direct climate pollution reduction benefits. Although the waste management sector emits the second smallest amount of greenhouse gases out of all six sectors,[ccxi] the region should still be prioritizing actions to reduce climate pollution from the waste management sector going forward. This is especially true looking at community outreach results from the GWPCAP planning process; community members ranked waste management as the second sector (out of six total) to be prioritized for implementation actions going forward during our series of Fall 2023-Winter 2024 public workshops. Please see below for a closer look at how waste management actions can contribute to or offset greenhouse gas emissions.

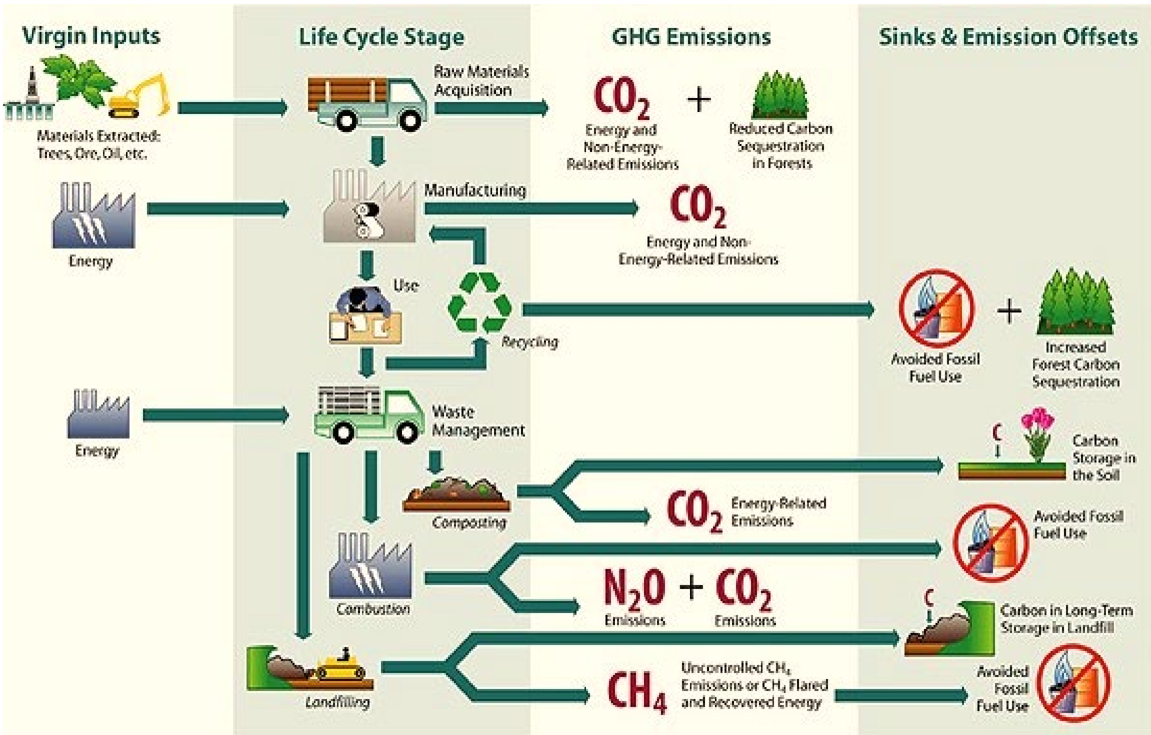


Image Credit: USEPA, State and Local Climate and Energy Program,

Solid Waste & Materials Management[ccxii]

Waste Management Emissions Contribution

Table 24: Emissions Contribution from Waste Management Sector, By Subsector in the Worcester, MA – CT MSA (2017)

Subsector	CO2 Equivalent Emissions (MT CO2e)	CH4 Equivalent Emissions (MT CH4)	N2O Equivalent Emissions (MT N2O)
Solid Waste Disposal	339,866	12,138	N/A
Biological Treatment of Waste	768	16	1
Incineration and Open Burning	13,998	0.08	18
Wastewater Treatment and Discharge	101,424	2,976	68
****Total:**	**456,055**	**15,130.08**	**87**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory –Weston & Sampson, 2024[ccxiii]

**Totals are inclusive of both Scope 1 (direct) and Scope 3 (indirect) emissions from waste management activities.

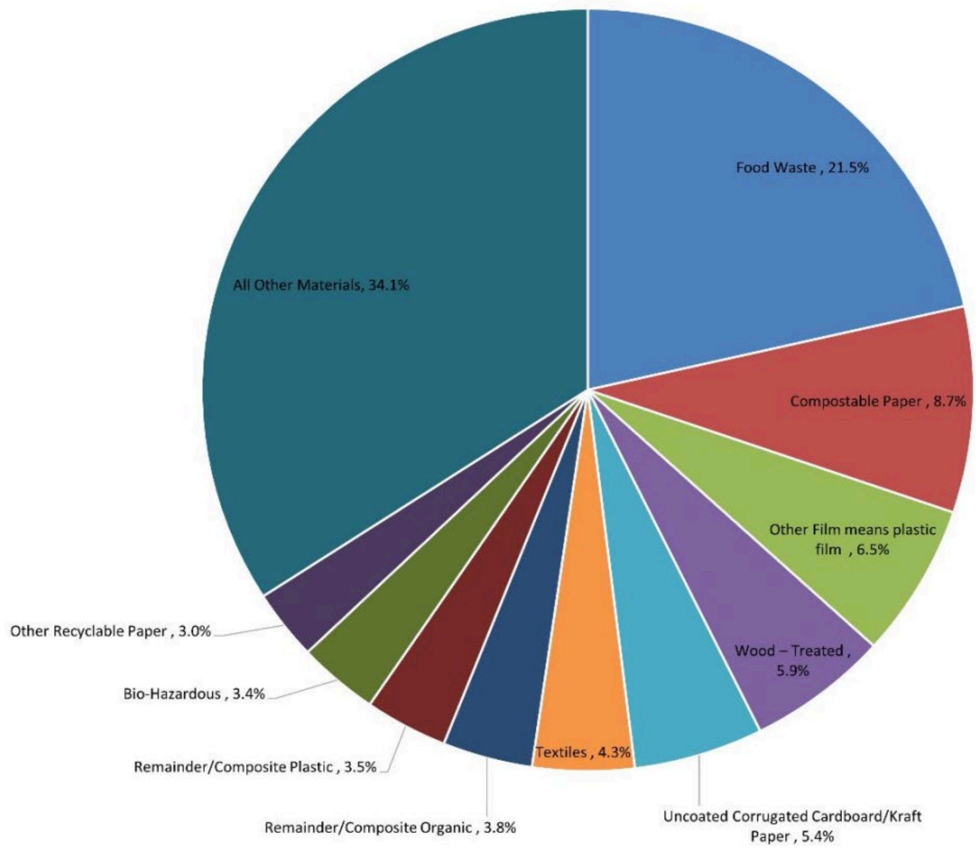
Within the Greater Worcester Region, emissions from solid waste disposal were the most common source of greenhouse gas emissions from the waste management sector in 2017. Solid waste disposal emissions account for roughly 74.5% of waste emissions alone, and 3.1% of total emissions within the MSA. Emissions from wastewater treatment and discharge account for the next largest share of emissions – these emissions account for 22.2% of total waste sector emissions vs. 0.9% of total emissions within the MSA. The second smallest emissions source is incineration and open burning of waste which contributes to 3.1% of waste sector emissions and 0.1% of total waste sector emissions. Finally, biological treatment of waste makes up less than 1% of both waste sector and total MSA emissions.

Regional Context

Massachusetts

Overall, the resiliency of Massachusetts' waste disposal infrastructure declined since 2010. As recycling markets continue to adapt, prices are slumping due to the lack of buyers, recycling costs are becoming more expensive, and recycling capacity continues to diminish across the Commonwealth.[ccxiv] One of Massachusetts' glass processors recently closed their facility in Milford, leaving roughly 2,000 tons of municipal glass without an end market every year.[ccxv] Landfilling capacity for the disposal of MSW shrank significantly over the past four decades, from over 300 landfills in 1980 to just 8 landfills as of June 2023.[ccxvi] Many of the state's few remaining landfills are predicted to reach capacity by 2030, which means that there is an apparent need to create new in-state/regional disposal capacity.

Top 10 Materials in the Trash, Massachusetts (2019)



Data Source: MassDEP 2030 Solid Waste Master Plan, 2021[ccxvii]

According to the above graphic, diverting food waste away from MSW streams will be essential going forward. Since 2010, the Commonwealth has already started this process. In 2014, the Commonwealth instituted a commercial organics disposal ban for facilities generating one ton or more of organic material per week. Additionally, perishable food reclamation efforts improved by 60%, anaerobic digestion capacity has increased by 600,000 total tons, and food waste collection programs started by businesses more than doubled since 2010. [ccxviii]

Connecticut

According to CT DEEP, about 35% of Connecticut's waste is diverted - 28% of Connecticut's waste is recycled and 7% is composted. The remaining amount of the state's waste is sent into Connecticut's municipal solid waste (MSW) stream, amounting to roughly 2.2 million tons per year.[ccxix] Within this MSW stream, around 41.4% is composed of compostable organics which includes food waste and other organics (22.3 % and 11.1% of total MSW, respectively).[ccxx] It is important to note that Connecticut does not have any active landfills that are utilized for the purpose of MSW disposal – active landfills across Connecticut are utilized for the disposal of bulky waste and special waste only – which means that in-state waste disposal capacity is generally limited.[ccxxi]

In addition, Material Innovation and Recycling Authority's (MIRA's) 2022 decision to halt waste-to-energy (WTE) operations at the Hartford Resources Recovery Facility (RRF) contributes to the overall reduction of in-state waste disposal capacity.[ccxxii] Connecticut's self-sufficiency deficit now sits at 40%, (or approximately 860,000 tons per year), and waste continues to be shipped out of the state to other receiving states, including Pennsylvania and Ohio, among others.[ccxxiii] Shipping the state's waste out of state is not only costly for municipalities and taxpayers, but it also contributes to greenhouse gas emissions in receiving states and creates environmental justice issues for low-income disadvantaged communities who live nearby these out-of-state landfills. Finally, over half of Connecticut's MSW is sent to in-state waste incinerators - roughly 60% according to Naugatuck Valley Council of Governments (NVCOG). All incineration facilities are found next to/within the boundary of many of Connecticut's EJ communities.[ccxxiv]

Connecticut has also started to implement more food waste recovery efforts. For example, the State of Connecticut awarded grants to 19 municipalities to aid with the development of unit-based pricing and food scrap diversion programming to "improve organics management across the region as of 2023. [ccxxv] One municipality, Meriden, Connecticut, was able to divert 13 tons of food scraps from landfills and incinerators by starting a Sustainable Materials Management Program.[ccxxvi]

Worcester, MA-CT MSA

Overall, the waste management sector accounts for 3.1% of total greenhouse gases emitted by the Worcester, MA – CT MSA region.[ccxxvii] Collected solid waste is either incinerated or sent to landfill, and collected organic waste is either sent to a compositing facility or to an anaerobic digestion facility. Wastewater is either sent to the Massachusetts Water Resource Authority (MWRA)'s Wastewater Treatment Plant in Clinton (where anaerobic digesters exist to treat biosolids from wastewater), or is treated at a local, municipal wastewater treatment plant. As a priority, this plan seeks to address both Scope 1 and 3 emissions associated with the production of solid waste across the Worcester, MA-Eastern CT region, as the total emissions associated with solid waste disposal are higher compared to other waste management subsectors/emissions sources within the MSA.

Table 25: Destination of Collected Disposed Waste

From Worcester, MA-CT MSA (2017)

Destination of Collected *Waste* Material*	Reported Quantity (tons)**	Percent of Collected Waste (%)
MA Incinerated*	487,948	66%
MA Landfilled*	201,010	27%
CT Combustion**	54,284	7%
CT Landfilled**	1,644	0%
Total:	**744,885**	**100%**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[ccxxviii]

*Please note that MA in this column refers to waste originating in the Worcester County, MA region, and CT refers to waste originating from the Eastern Connecticut region.

** Percentages are inclusive of waste disposed both in and out of state.

Table 26: Destination of Collected Organic Material

From Worcester, MA-CT MSA (2017)

Destination of Collected *Organic* Material	Percent of Organic Waste (%)	Reported Quantity (tons)
Composting Facility	58%	4,418.72
Anaerobic Digestion Facility	42%	3,146.28
Organics Total:	**100%**	**7,565**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[ccxxix]

According to the Massachusetts Department of Environmental Protection (MassDEP) and the Connecticut Department of Energy and Environmental Protection (CT DEEP), solid waste disposal capacity across the MSA is both limited and decreasing. This trend will continue if no future interventions are implemented in the future to improve solid waste management and disposal capacity on the local, regional, or state levels in the future (which is unlikely given ongoing state efforts to-date).

Community Engagement Workshops: Waste Management Sector Results

Sector Prioritization Activity

Overall, community members living and working within the MSA ranked the waste management sector as second priority (tied with the electricity sector) in terms of where they want to see funds being spent going forward to reduce climate pollution across the region.

Goal Prioritization Activity

Please see the table below to see how community members ranked the plan's draft goals as they relate to the waste management sector. Overall, residents are most concerned with contamination in residential and commercial recycling streams, as contamination can cause materials to be landfilled instead of being recycled.

Goal / Option	Rank
Improve the quality of/reduce contamination in residential and commercial recycling streams	1
Sustainably manage disposal facilities within the MSA	2
Phase out difficult to recycle materials	3
Reduce the overall amount of waste being disposed, especially food waste	4

Feedback from Discussions

Several major themes appeared from the community outreach results, including:

1. Targeted **outreach and education** to businesses, residents and Towns about reuse, recycling and disposal best practices, and the negative effects of waste stream contamination.

2. The need for more **regional partnerships** to build up local **circular economies**.

3. The need for more **local and regional composting programs and partnerships**, including curbside pick-up services, added drop-off locations, and low-cost composting equipment for multi-family households, schools, senior centers and businesses.

4. **Financial incentives** for businesses, residents and Towns to separate solid waste before disposal happens, especially for disadvantaged individuals/entities in low-income disadvantaged groups.

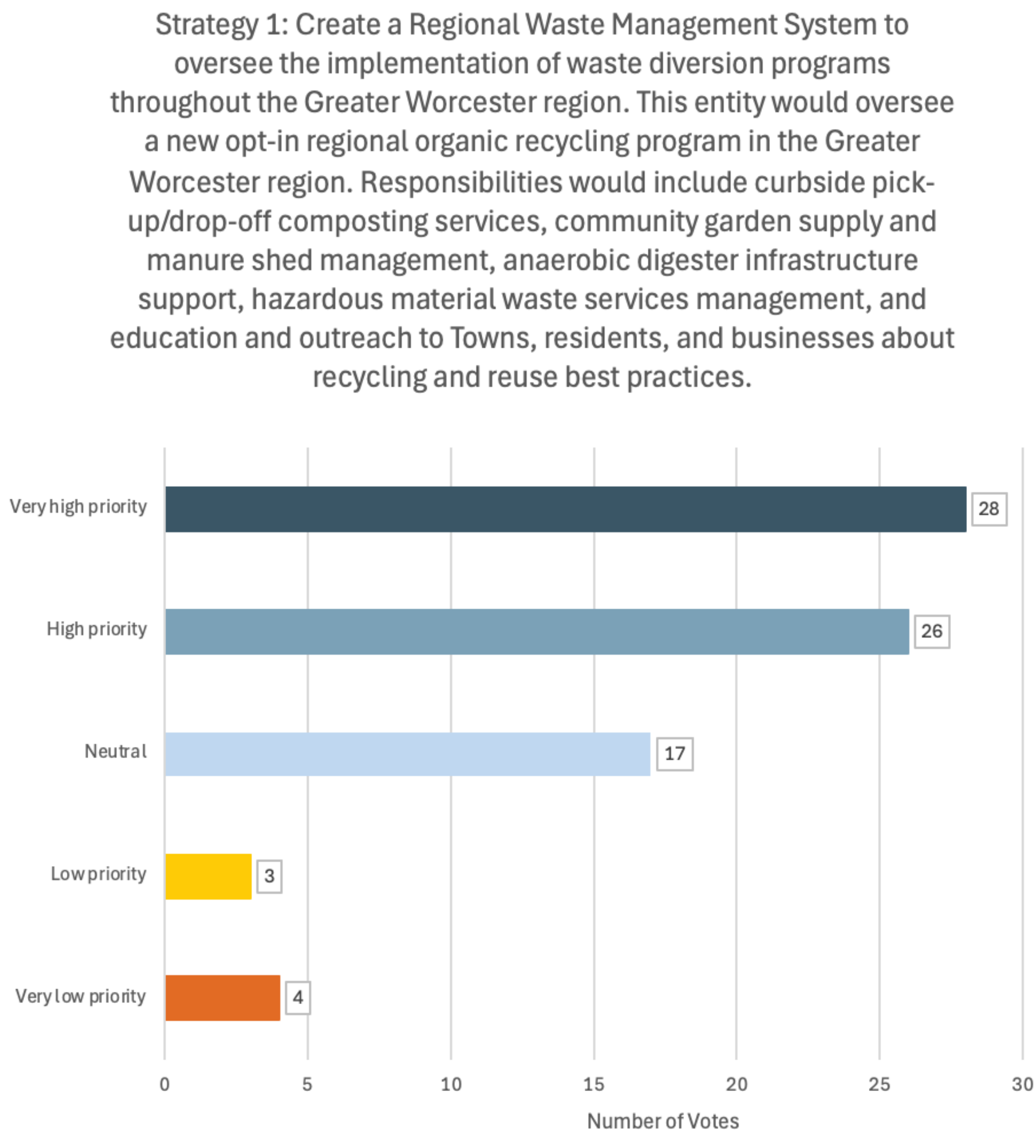
5. **Financing and technical assistance** for the development of new **climate-smart technologies** on the local level, including anaerobic digesters and liquefaction infrastructure; and

6. **Material bans** on the local level.

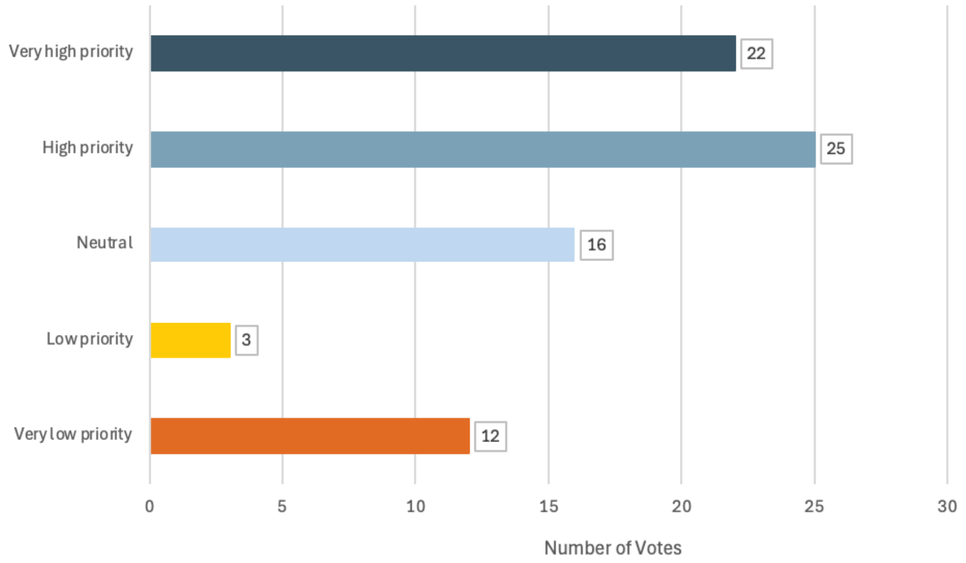
Waste Management & Agriculture, Natural and Working Lands

Break-Out Group, Worcester, MA Workshop - January 18, 2024

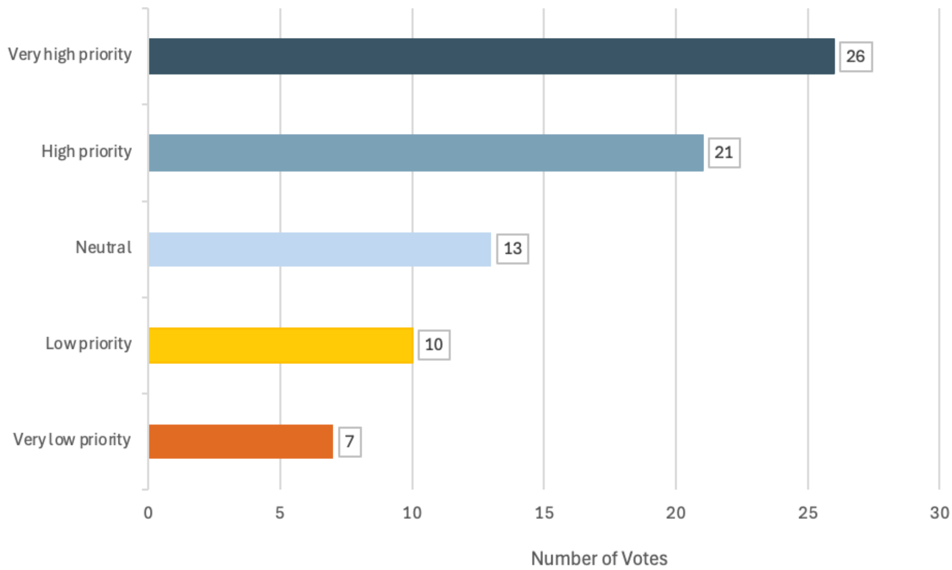
Strategy Prioritization Activity



Strategy 2: Divert organic materials, wastewater biosolids, and animal waste byproducts from landfills to anaerobic digestor facilities to help reduce greenhouse gas emissions and create new green jobs for LIDAC communities. Reuse the energy created by anaerobic digestors as electricity to power public buildings and public transportation. Local and regional partnerships through the EPA's AgSTAR Program are encouraged.



Strategy 3: Restrict use of plastic bags, straws, bottles, takeout containers and laundry detergent containers on the local and regional level. Develop new ordinances restricting the use of single-use plastics and offer new incentives and initiatives to increase demand for recycled materials.



Generally, survey respondents showed that all 3 of our proposed waste management actions are favorable overall, despite waste contributing a much smaller number of emissions in our region. Strategies 1 and 3 were both ranked as very high priority, followed by Strategy 2 which was ranked as high priority. Overall, waste management was prioritized very highly by residents throughout the duration of the community engagement process for this plan, including our community workshop activity results.

Waste Management Sector: Goals, Strategies and Actions

Goals

Goal 1: Reduce the overall amount of waste being disposed - **CRITICAL URGENCY**

Goal 2: Reduce contamination in/improve the quality of residential recycling streams – **VERY IMPORTANT**

Goal 3: Phase out difficult to recycle materials – **VERY IMPORTANT**

Goal 4: Sustainably manage disposal facilities within the MSA – **VERY IMPORTANT**

Table 27: Priority Waste Management Strategies

Goal #	Strategy	Public Priority	Amount of waste diverted (tons)	Estimated GHG Reduction (MTCO2e/year)	Muni. Cost Savings ($)	Approx. Costs ($)	LIDAC Benefits	Authority to Implement
1	1. Create local/ regional composting programs and establish a Regional Waste Management Entity to oversee the implement-ation of organics and waste diversion programs across the MSA.	Very High	55,866	47,411	High	Medium	Medium	Local, regional
1,4	2. Create new anaerobic digester infrastructure and foster local partner-ships to guarantee a steady supply of organics, especially partnerships with LIDACs/ stakeholders with connect-ions to LIDACs	High Priority	42,000	17,228	Medium	High	High	Local, regional
1, 2, 3	3. Restrict the use of plastic bags, bottles, takeout containers, and detergent containers across the MSA.	Very High	89,386	25,478	High	Low	Medium	Local, regional, state

Waste Management: Strategy Narratives

Strategy 1: Create local/regional composting programs and establish a Regional Waste Management Entity to oversee the implementation of organics and other waste diversion programs across the MSA.

Overview

Strategy number one encompasses creating an opt-in regional organics recycling program in the Greater Worcester Region and creating a Regional Waste Management Entity to oversee the implementation of organics recycling programs and other waste diversion programs across the MSA. This entity would also be responsible for inclusive education and outreach to Towns and residents about unit-based pricing/ Pay-As-You-Throw, recycling best-practices, and local community garden needs.

Emissions Quantification

According to Weston & Sampson, this strategy will reduce the amount of MTCO2e by 47,411 MTCO2e/year. Weston & Sampson used MassDEP's Solid Waste Master Plan goal of a 30% reduction of waste by 2030, which assumes that a 15% reduction can be attributable to this strategy. This equates to 111,733 tons per year by 2030. There would thus be an increase in 55,866 tons if half of the organic waste is diverted to composting or anaerobic digestion.[ccxxx]

What is a Regional Waste Entity?

A Regional Waste Entity can take multiple forms – but overall, this term refers to municipalities located within a specific geographic boundary joining together to delegate waste management responsibilities to a central authority, association or organization.[ccxxxi]

What are the potential benefits and challenges?

The benefits of forming a Regional Waste Management Entity are extensive, especially as they pertain to the managing of organic waste. First, economies of scale will be more easily achieved for food scrap diversion and the reduction of waste overall. This means that municipalities will save money on disposal costs and composting contracts in the long-term as this new entity starts managing joint procurement of services on municipalities' behalf. Joint procurement is also beneficial for improving already limited municipal capacity for many of our smaller, more rural towns in the region. This new entity would also ensure that new anaerobic digesters and local community gardens have a guaranteed supply of organics as the entity helps to coordinate the movement of organics from areas of surplus to areas of need across the MSA.

According to Western Connecticut Council of Governments (WestCOG), Regional Waste Management Entities can also ensure that public outreach and education initiatives are unified, and that messaging is consistent from municipality to municipality. For example, this entity could provide unified educational campaigns about important subject matter such as MassDEP's and MassRecycle's ongoing recycling education campaigns, and best practices aimed at diverting organics and reducing waste from the source.[ccxxxii] The education responsibility would now fall on this new regional entity instead of each individual municipality. This entity would also focus on education about existing recycling and waste diversion incentives for businesses and institutions, as well as education and technical assistance for municipalities on the planning and implementation of new Pay-As-You-Throw/Unit-Based Pricing programs.

Outside of organics waste management, this entity would also manage expanding and continuing waste reduction programs that already exist at the state and local levels with a focus on including businesses, schools, institutions and senior centers in the waste reduction, reuse, and incentives education process. Finally, this new Regional Waste Management Entity could manage hazardous waste pick-up contracts and services, the implementation of methane recapture programs and projects, and implementation of forestry waste management projects.

It is likely that one of the only significant challenges will be the long-term operating costs of the new Regional Waste Entity. It is crucial that there is a plan for ongoing operation and management of this entity and that there is adequate funding to keep the entity in operation.

Local/Regional Composting Program(s) Actions

Expanding municipal/local composting infrastructure, educating the public about waste reduction, and providing residents with composting supplies will be essential as more local/regional composting programs appear across the region. A program like this can reduce the amount of organic waste produced by 55,866 tons/year. A newly established Regional Waste Management Entity would also play a crucial role in helping to manage some of these composting programs by hiring new regional coordinators to establish and/or expand on municipal composting infrastructure on the municipal and regional level; this would entail managing co-collection for curbside or transfer station programs and purchasing materials such as bags/other receptables, as necessary. Waste reduction outreach campaigns should be targeted towards LIDAC Census Tract areas and multi-unit residences, and composting supplies should be made free or low-cost to low-income households.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced GHG emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced disposal costs
Risk of climate change impacts is reduced (i.e., heat, flooding)	Reduced environmental contamination
Reduced air pollution (i.e., PM2.5)	Reduced healthcare costs
	Decreased morbidity incidence
	Capacity building through local partnerships
	Improved municipal capacity

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, unemployment burden and elevated flood risk.

Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this action, creating new local/regional composting programs and establishing a Regional Waste Management Entity to help facilitate this organics/other waste management process is ranked as high priority for this plan. In terms of authority to implement, local and regional entities have a high authority to implement this strategy. Technical assistance, public/other stakeholder engagement work, project management, grant administration, procurement management work, and composting infrastructure costs about this strategy should all be prioritized for IRA funding. It is important to note that municipalities would be able to "opt in" once a Regional Waste Management Entity is established. There is also potential for this agency to grow outside of the MSA, but added state-wide authority would likely be needed to implement this.

Strategy 2: Create new anaerobic digester infrastructure and foster local partnerships to guarantee a steady supply of organics, especially partnerships with LIDACs/stakeholders with connections to LIDACs.

Overview

Strategy number two encompasses diverting organic materials, wastewater biosolids, and animal waste byproducts from landfills to anaerobic digester facilities to help reduce greenhouse gas emissions, to create renewable sources of energy, and to aid in the creation of new green jobs. This strategy also emphasizes that local/regional partnerships with LIDACs and stakeholders with connections to LIDACs are needed to sustain a constant supply of organics for these new digesters.

Emissions Reduction Quantification

According to Weston & Sampson, this strategy will reduce the amount of MTCO2e by 17,228 MTCO2e/year if three digesters are constructed within the MSA. Weston & Sampson's quantification method included using data from the Barstow Anaerobic Digester facility located in Hadley, MA to calculate emissions from a reduction for landfilled and combusted waste, an increase for anaerobically digested waste, as well as a decrease in grid supplied kilowatt-hours.[ccxxxiii]

What is anaerobic digestion and how does it fit into the wasted food scale?

According to the USEPA, anaerobic digestion is defined as "…the process of breaking down organic materials, such as wasted food, within an oxygen-free environment."[ccxxxiv] Anaerobic digestion generates biogas as microorganisms break down food and animal waste within the digester - this biogas can be used as a source of renewable energy on the local level. Any air pollutants, like sulfur, are stripped from the mixture before the biogas is burned to create electricity. In addition to the renewable energy benefits of biogas creation, anaerobic digesters also produce digestate or biosolids that can be used as fertilizer, soil amendment or animal bedding.[ccxxxv] There are three main types of anaerobic digesters: 1) stand-alone digesters that focus on processing wasted food only, 2) on-farm digesters that co-digest food waste and manure together, and 3) digesters placed at a water resource recovery facility that co-digest food waste and wastewater solids together.[ccxxxvi]

According to the EPA, anaerobic digestion and composting are generally preferred over landfilling, wastewater treatment, and incineration to manage food waste if feeding residents and animals is not immediately possible - creating added anaerobic digester infrastructure will be necessary as food waste will likely continue to be produced in the short-term. Landfilling and wastewater treatment both generate methane emissions during the breakdown and processing of food waste, and the valuable nutrients that remain may not be recovered for beneficial use on the local or regional levels.[ccxxxvii] Wasted food also generates little renewable energy during the incineration process, which makes incineration one of the least suitable methods for renewable energy creation if primarily food waste is being used as an input. Waste incinerators also create harmful air and climate pollution which puts LIDAC communities at greater risk of developing health-related issues over time.

What are the benefits and challenges?

"There are substantial benefits to building more anaerobic digestion infrastructure across the MSA. First, all digestion byproducts are reused throughout the process. The heat produced from the anaerobic digestion process can be reused on-site to heat greenhouses, which could lead to extended growing seasons for local farmers.

Additionally, burning the excess biogas in generators can help create renewable sources of electricity – this excess electricity can be reused on site, sold to local gas grids or road fuel markets. While this burning process does produce comparatively much smaller amounts of CO_2, the process is still carbon-neutral and does not add to the overall amount of global greenhouse gas emissions. [ccxxxviii]Plus, the carbon that is produced from the anaerobic digestion process can be captured and stored for later use.[ccxxxix] Other benefits of anaerobic digestion include the potential for reductions in fugitive methane emissions, air pollutants, and harmful odors, and the potential for improved water quality on the local level. Additionally, as more digesters are built across the MSA, transportation emissions from transporting excess food waste to these facilities will decrease as well since the vehicles will not have as far a distance to travel.

In general, Massachusetts and Connecticut both have clear needs for more anaerobic digesters, but one drawback is usually the funds needed to build the digester. According to the EPA, capital costs of building a farm digester can range between $500,000 up to ~$5,000,000.[ccxl] Additionally, anaerobic digesters need a consistent stream of food and manure waste to be able to continue to operate. This shows the need for more local and regional partnerships during the planning process to divert food waste away from residences, commercial buildings, schools and hospitals to guarantee this supply of organics. Partnering with local non-profits, businesses, hospitals, schools and other farms that have connections with/are located within LIDAC census tracts should be prioritized to ensure that the cost burdens of food waste disposal are taken away from LIDACs.

One final drawback to consider is the risk of PFAS contamination from the digestate after it has been applied to soils as a fertilizer. From the limited EPA data we do have on this issue, it is possible that food packaging, compostable service ware, fish and meat could be the largest contributors of PFAS in organic food waste.[ccxli] According to the EPA, exposure to PFAS for extended periods of time has been associated with the development of cancer, hormonal disruptions and hypothyroidism.[ccxlii] Please visit https://www.epa.gov/pfas to stay up to date about how the EPA plans to address PFAS contamination in the future.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Capacity building through local partnerships
Risk of climate change impacts is reduced (i.e., heat, flooding)	Improved access to affordable and healthy local foods
Reduced air pollution (i.e., PM2.5)	Reduced healthcare costs
	Decreased morbidity incidence
	Reduced disposal costs

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, unemployment burden, low income and elevated flood risk.

Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this action, creating new anaerobic digester infrastructure and creating partnerships to guarantee the supply of organics is ranked as medium priority for this plan. In terms of authority to implement, local and regional entities have a high authority to implement this strategy. Grant programs, technical assistance, outreach work, and project management work about the development of anaerobic digester infrastructure should all be prioritized for IRA funding. The creation of local and regional partnerships via the EPA's AgSTAR Program are encouraged.

Strategy 3: Restrict the use of plastic bags, bottles, takeout containers, and detergent containers across the MSA.

Overview

Strategy number three concerns restricting the use of plastic bags, bottles, takeout containers, straws and detergent containers across the MSA to help reduce greenhouse gas emissions and promote workforce development opportunities. More specifically, this strategy would encompass developing new ordinances restricting the use of single use plastics and offering new incentives and initiatives to increase demand for recycled materials. Improving opportunities for creative reuse of plastics would also help to create and sustain a strong circular economy in the region.

Emissions Quantification

MassDEP's 2021 Massachusetts Solid Waste Master Plan identified plastics as making up 12% of the state's waste stream. When this figure is applied to the quantity of waste that the MSA is responsible for, this would equal 89,386 tons of waste. A 60% reduction in this quantity of waste would yield potential emissions savings of 25,478 MTCO2e per year within the MSA.

What are the benefits and challenges?

Creating new local ordinances to restrict the use of single-use plastics is one way to reduce the overall use of the plastics and to help reduce overall demand for plastic products. Local ordinances alone will not solve the single-use plastics in the trash issue though - recycling and reuse markets still need to be further incentivized and established on a regional scale. These types of ordinances would directly gear consumers towards choosing more sustainable, reusable products.

Workforce development opportunities and partnerships should be prioritized that focus on the refurbishment of hard to recycle materials, including other types of waste such as construction material, electronics, home supplies, automotive waste and textile waste. LIDACs and residents experiencing unemployment burden should be prioritized for workforce development opportunities for these new reuse programs.

Although buying reusable materials may be more expensive up front, it is also more cost-effective in the long-term compared to often buying single-use materials. Businesses are adopting more sustainable models that involve reusing and refilling materials through bulk purchasing rather than buying single-use materials and throwing them away. For such models to succeed, consumers must be willing to adapt their habits and lifestyles. More intrinsic incentives exist for these models, such as built-in sustainable branding for businesses and less waste to manage for individuals. However, regional entities, municipalities and organizations could take incentives to the next level through rewards and charges. Some waste management authorities and municipalities have adopted pay-as-you-throw (PAYT) models, where residents are charged based on the amount they throw away.[ccxliii] Rewards-based models, such as vouchers, can also be used to incentivize residents and businesses to generate less waste and recycle more often.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced GHG emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Capacity building through local partnerships
Risk of climate change impacts is reduced (i.e., heat, flooding)	Reduced healthcare costs
Reduced air pollution (i.e., PM2.5)	Decreased morbidity incidence
	Reduced environmental contamination
	Reduced disposal costs

LIDACs affected: All LIDACS previously identified, Census Tracts that experience high percentages of linguistic isolation, unemployment burden and elevated flood risk.

Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this action, restricting the use of plastic bags, bottles, takeout containers, and detergent containers across the MSA is ranked as medium priority for this plan. In terms of authority to implement, local entities have a high authority to implement single-use plastic restrictions. Regarding workforce and market development projects, local and regional entities have authority to implement; grants/grants management work, outreach, project development, purchasing of material/equipment, workforce training, should all be prioritized for IRA funding.

Agricultural, Natural & Working Lands

Agricultural, Natural and Working Lands

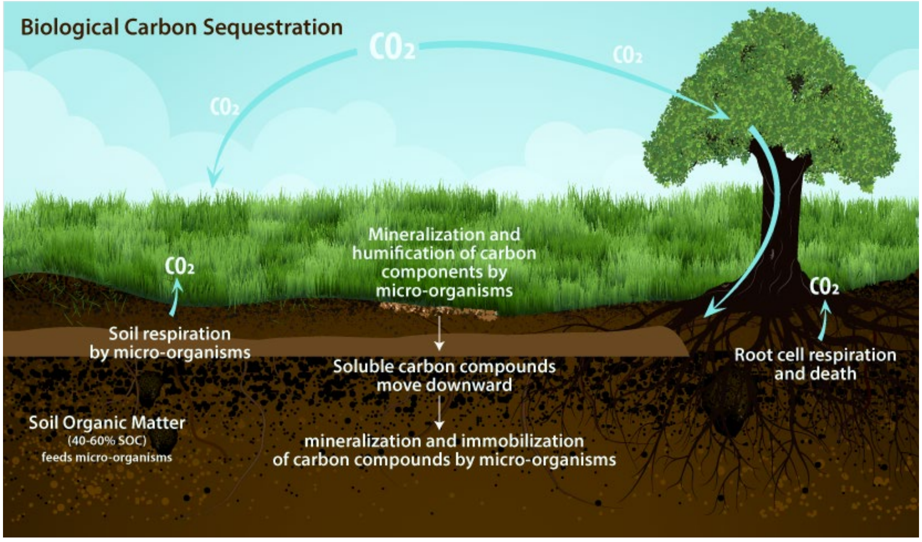
The Greater Worcester Region encompasses a variety of land uses and land cover types, from urban areas and densely populated residential settlements to large swaths of forestlands. The Intergovernmental Panel on Climate Change (IPCC) recognizes six major categories of land types: forestland, cropland, grassland, wetlands, settlements, and other lands (bare soil, rock, ice, and all other lands). [ccxliv] This section of the GWPCAP focuses on agricultural, natural and working lands. It is worth noting that in the context of climate pollution, forestland and other natural lands play an entirely different role than agricultural land; nonetheless, both represent an opportunity for increased sustainability and pollution reduction.

The 2021 Massachusetts Climate Law defines natural and working lands as "lands within the Commonwealth that: (i) are actively used by an agricultural owner or operator for an agricultural operation that includes, but is not limited to, active engagement in farming or ranching; (ii) produce forest products; (iii) consist of forests, grasslands, freshwater and riparian systems, wetlands, coastal and estuarine areas, watersheds, wildlands or wildlife habitats; or (iv) are used for recreational purposes, including parks, urban and community forests, trails or other similar open space land."[ccxlv] Although this definition was crafted to describe lands within Massachusetts, it is widely applicable and may be used to describe natural and working lands nearly anywhere, including in Connecticut.

Massachusetts and Connecticut are the fifth and sixth most densely populated states in the country, respectively. [ccxlvi] Nevertheless, Massachusetts is 57% forested and Connecticut is 60% forested.[ccxlvii] This juxtaposition between high numbers of both people and trees highlights the Greater Worcester Region's longtime commitment to preserving its natural resources while accommodating a growing population.

How do Agricultural, Natural and Working Lands Contribute to Climate Pollution?

Natural lands and resources capture and release carbon dioxide throughout the carbon cycle, storing carbon in biomass, or plant materials, animal waste, and soils.[ccxlviii] Specifically, plants absorb carbon dioxide as they grow and store it in perennial aboveground or belowground biomass. Soils and dead organic matter can also store carbon, depending on how the soil is managed and climatological conditions. The storage of carbon in plants, dead organic matter, and soils is called "biological carbon sequestration" or "carbon sinks". In 2021, the net carbon dioxide (CO2) removed from the atmosphere by United States' land use, land use change, and forestry sector was 12% of the year's total emissions. [ccxlix]



Source: The State of California – CalRecycle [ccl]

On the other hand, agricultural activities contribute to GHG emissions in many ways, such as the management of land, crops, soil, manure, and livestock. Specifically, agricultural practices such as the application of organic and synthetic fertilizers can lead to the increased availability of nitrogen in soils and result in emissions of nitrous oxide (N2O). Other activities that may lead to an increase in nitrous oxide emissions include the growing of nitrogen fixing crops, the drainage of organic soils, or irrigation practices. In the United States, the management of agricultural soils accounts for over half the agricultural sector's GHG emissions. [ccli]

Improving sustainable land-use and farm management practices while enhancing capacity for biological carbon sequestration would capitalize on the opportunity for the Region's agricultural, natural and working lands sector to offset emissions from other major climate polluting sectors.

Agricultural, Natural and Working Lands: Emissions Contributions

In the Greater Worcester Region, the application of synthetic fertilizer on Massachusetts and Connecticut farmland produced 129.12 metric tons of nitrous oxide (N2O) emissions in 2017. Compared to other major climate polluting sectors and subsectors within the Region, however, the agriculture sector only emitted 0.30% of the total GHG emissions for 2017. Although emissions from the Region's agricultural sector are comparably insignificant, they represent an opportunity for increased sustainability and net-zero emissions within one major sector. Additionally, carbon sequestration from the Region's natural lands makes up for the emissions associated with the application of synthetic fertilizer tenfold; in 2017, the Region's canopy captured over 1.99 million metric tons of carbon dioxide equivalent emissions (CO2e). [cclii]

Table 28: Greater Worcester Agriculture, Natural and Working Lands Emissions Contributions

Sector	Subsector	CO2 Equivalent Emissions (MT CO2e)	CH4 Emissions (MT CH4)	N2O Emissions (MT N2O)
Agriculture	Commercial Fertilizer	34,217	N/A	129.12
Natural and Working Lands	Carbon Sequestration	(1,993,374.84)	N/A	N/A
****Total:**		**(1,959,157.84)**	**N/A**	**129.12**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[ccliii]

Agricultural, Natural and Working Lands: Regional Context

Massachusetts

Massachusetts natural and working lands store at least 0.6 gigatons of carbon, equivalent to the past 25 years of GHG emissions in the state. While forestland covers 57% of the state, croplands and grasslands cover 7% of the state. More specifically, Massachusetts forestlands sequester 5.8 million metric tons of carbon dioxide equivalent emissions (CO2e) annually while croplands and grasslands emit 0.3 million metric tons of CO2e annually. The Massachusetts Clean Energy and Climate Plan (CECP) acknowledges that to meet the goal of net zero emissions by 2050, the state needs to significantly reduce its economic GHG emissions while also securing additional carbon sequestration capacity. However, the need to increase short-term carbon sequestration capacity must consider the long-term ecosystem services NWL provide, such as wildlife habitat, clean air and water, and recreational opportunities.[ccliv]

Connecticut

Forestland covers 60% of the State of Connecticut and can sequester up to 40 tons of carbon dioxide per year per hectare.[cclv] Meanwhile, the State has a total of 381,539 acres of farmland and the agricultural sector contributed 1% of Connecticut's total GHG emissions in 2019.[cclvi] However, according to American Farmland Trust's Farms Under Threat, 23,000 acres of prime agricultural soils were developed or otherwise compromised in Connecticut between 2001 and 2016. [cclvii] The Connecticut Department of Energy and Environmental Protection (DEEP) is committed to conserving both its existing forestland and active farmland, while sustainably managing both assets. Specifically, the Connecticut DEEP recognizes the significant role that carbon sequestration through natural lands plays in reaching the goal of net-zero emissions and is pursuing "no-net loss forest" policy.[cclviii]

Worcester, MA-CT MSA

Both Connecticut and Massachusetts require each municipality to appoint a Tree Warden. Tree Wardens are public officials responsible for trees along the public right-of-way. Often collaborating with staff from the Department of Public Works and Highway Departments, Tree Wardens are tasked with managing the maintenance, removal and planting of all public shade trees. Municipal Tree Wardens within the Worcester, MA-CT MSA are vital to the conservation of public trees, their ecosystem services, and their carbon sequestration capacity. [cclix]

In total, the Greater Worcester Region's agricultural sector emitted 34,216.50 metric tons of carbon dioxide equivalent emissions (CO2e) into the atmosphere in 2017. These emissions stem directly from the application of synthetic fertilizer on the Region's farms. Meanwhile, the region's natural lands captured nearly 2 million metric tons of carbon dioxide equivalent emissions (CO2e) in 2017. [cclx]

Table 29: Massachusetts Land in Farms

County	Percent (%)	County Notes	MSA (Sq Mi)	County (Sq Mi)	Percent (%) of County in MSA	Percent (%) of Farms by County
Worcester	21.7	Only excludes Milford and Southborough	1,487	1,511	98	21.35
Middlesex	8.6	Includes Ashby, Ayer, Groton, Townsend, Shirley	114	818	14	1.20
**Total:	30.30		Percent (%) of State Total MSA Adjusted			22.60

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cclxi]

Table 30: Connecticut Land in Farms

County	Percent (%)	County Notes	MSA (Sq Mi)	County (Sq Mi)	Percent (%) of County in MSA	Percent (%) of Farms by County
Windham	13.6	Entire County	521	521	100	13.6

Tolland	9.3	Union Only	29.8	417	7	0.7
New London	15.8	Voluntown only	39.8	772	5	0.8
****Total:**	**38.70**		**Percent (%) of State Total MSA Adjusted**			**15.10**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cclxii]

Table 31: Greater Worcester Region – Emissions from Commercial Fertilizer Application

Subsector: Commercial Fertilizer	Metric Tons of Carbon Dioxide Equivalent Emissions (MT CO2e)	N2O Equivalent Emissions (MT N2O)
Commercial fertilizer application in MA	27,184.90	103
Commercial fertilizer application in CT	7,031.61	27
	34,216.50	**129.12**

Data Source: Worcester, MA-CT Metropolitan Statistical Area

Regional Greenhouse Gas Emissions Inventory Weston & Sampson, 2024[cclxiii]

Agricultural, Natural and Working Lands: Public Engagement

Sector Prioritization Activity

During the Greater Worcester Region's Climate Pollution Reduction Strategies Public Workshop series, CMRPC asked attendees to vote on which of the six major climate polluting sectors they would like to see future investments funneled to. Attendees were given two "tickets" and were asked to place them into boxes corresponding to the sector(s) they would prioritize. Overall, Agriculture, Natural, and Working Lands received the third highest number of investments (Waste & Electricity sectors were tied for second).

Goal Prioritization Activity

Workshop attendees were also asked to rank four draft goals related to each of the six major climate polluting sectors. The table below includes the draft goals for the Greater Worcester Region's Agriculture, Natural, and Working Lands Sector and the results from the goal prioritization activity:

Goal	Overall Rank
Reduce/disincentivize land clearing and permanently protect land and water	1
Increase carbon sequestration capacity	2
Scale-up sustainable land use practices	3
Improve livestock and manure management	4

Feedback from Discussions

Following a brief presentation, workshop attendees participated in lively discussions about the six major polluting sectors and their strategies for pollution reduction. Throughout the discussions, several major themes emerged related the Agriculture, Natural and Working Lands sector:

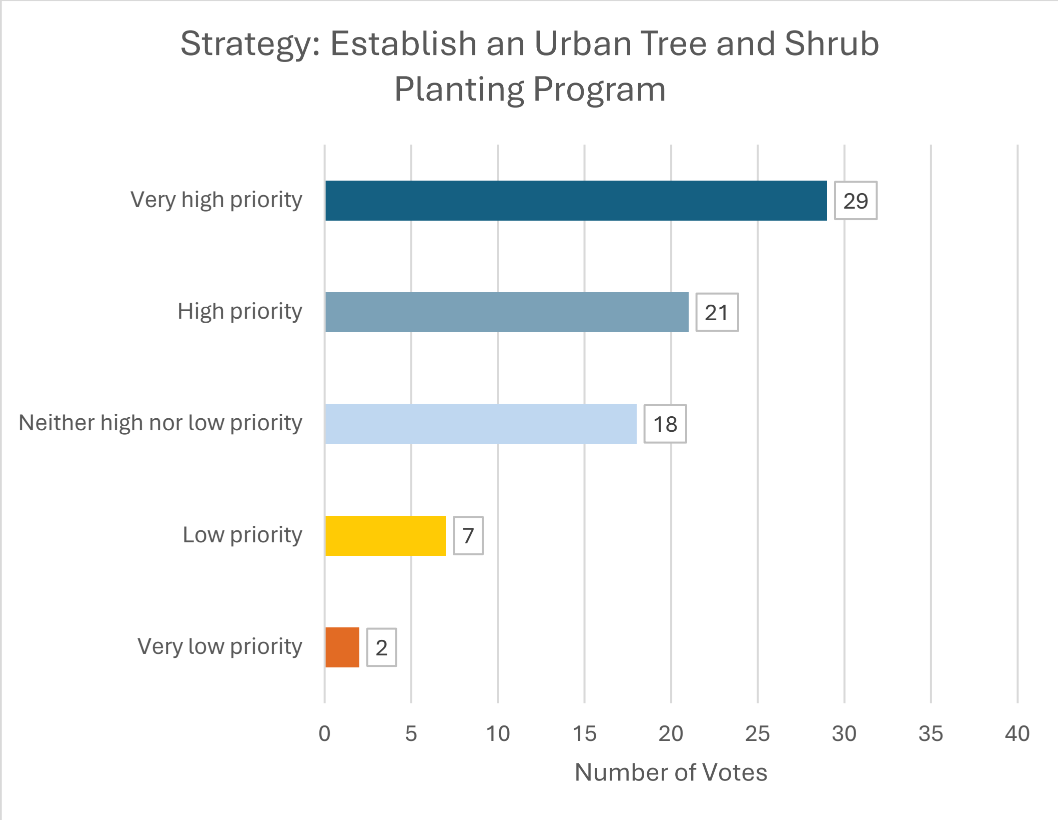
1. **The region must scale-up tree planting efforts and forestland protections as a method of biological carbon sequestration.** Forestlands also provide various ecosystem services, such as improved water and soil health. Additionally, forestlands provide social and economic benefits, such as shade during extreme heat events that may protect vulnerable populations and decrease energy consumption. Priorities from other sectors were also considered throughout discussions about forestland, such as reducing land clearing for solar energy systems and transportation infrastructure by incentivizing actions related to solar canopies, public transit, and active transportation.
2. **Bolstering small, locally owned farms and young farmers promotes local food production and elevates local food systems.** Local farms and farmers are essential to overall food production and food security. However, farm owners and managers face various challenges, from high property costs to the effects of climate change. To support local food production, local farms and farmers must be financially and technically supported. This includes young farmers in or near disadvantaged communities, both of which are essential to the future of the agricultural sector and equitable access to healthy, local food.
3. **Combating the spread of invasive species and pests is imperative to protecting native plants and animal species.** As climate changes and extreme weather events occur more frequently, invasive species and pests thrive. To

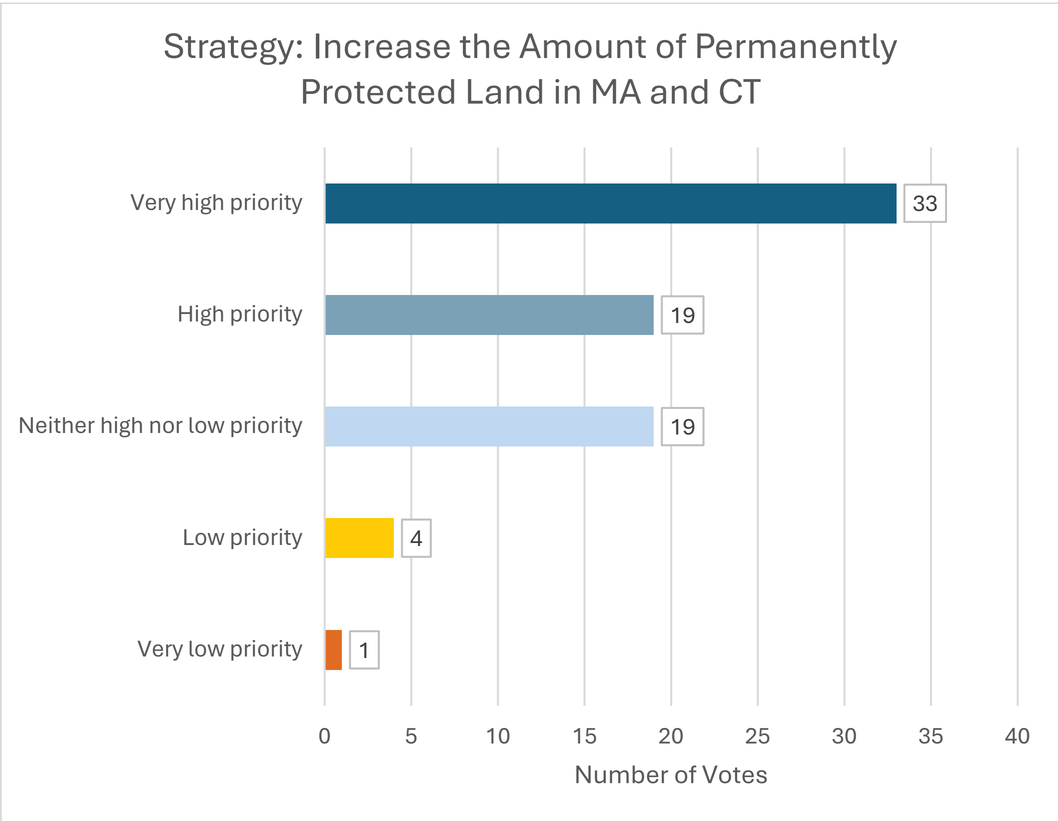
protect native plants and animals, municipalities, state entities, and other landowners may consider taking direct action to mitigate the spread of invasive species.

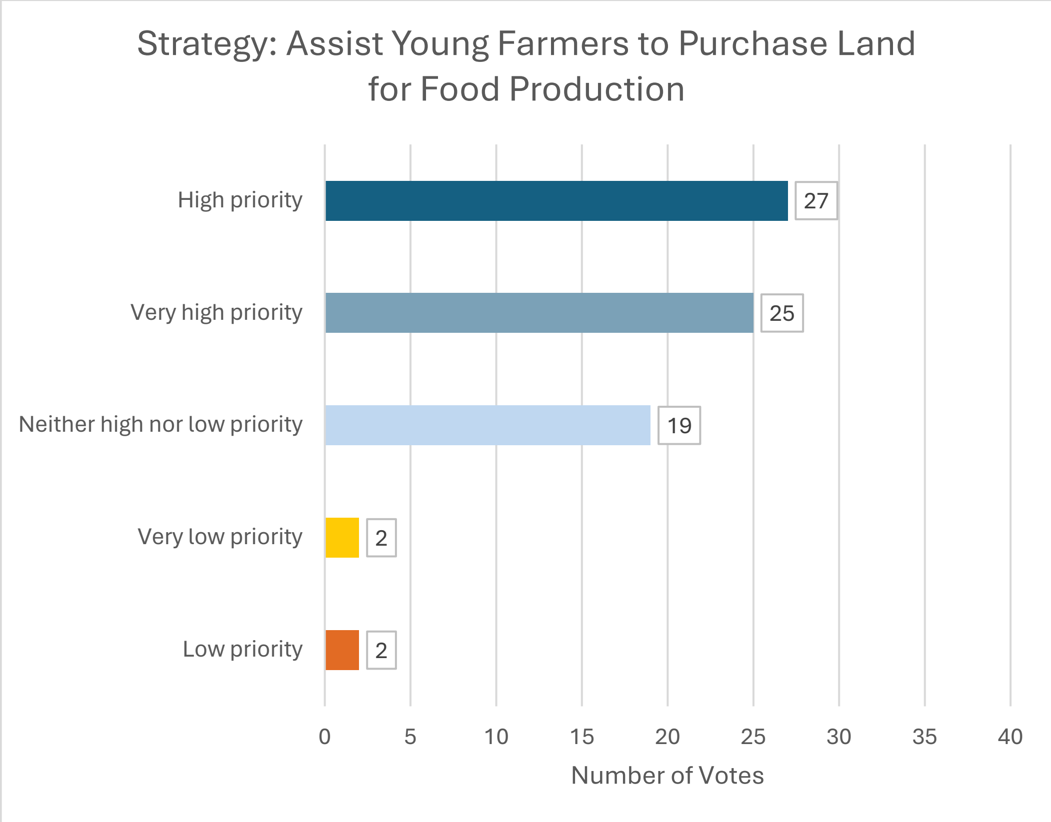
4. **Harnessing agricultural and forestry waste for energy production.** Organic waste from agriculture and forestry may include manure, food waste, and trees from land clearing. With a more comprehensive, regional approach to waste management, organic waste could be distributed to anaerobic digestors to produce biogas, which is comprised mostly of methane (CH4) and carbon dioxide (CO2).[cclxiv] Rather than disposing of these organic materials and allowing GHGs to be emitted into the atmosphere, they may be collected for energy production.
5. **Prioritizing water health, wetland health, and overall watershed health improves the health of local ecosystems.** When the health of a waterbody suffers, it may have a rippling effect throughout its entire subbasin and watershed. When the health of a subbasin or watershed is threatened, it may have rippling effects on air and soil quality, affecting plants, animals, and people.
6. **Implementing sustainable land use practices protects local ecosystems while mitigating climate pollution.** Sustainable land use practices may include improving management of agricultural soils, crops, and livestock and instituting low-impact development and cluster development bylaws.

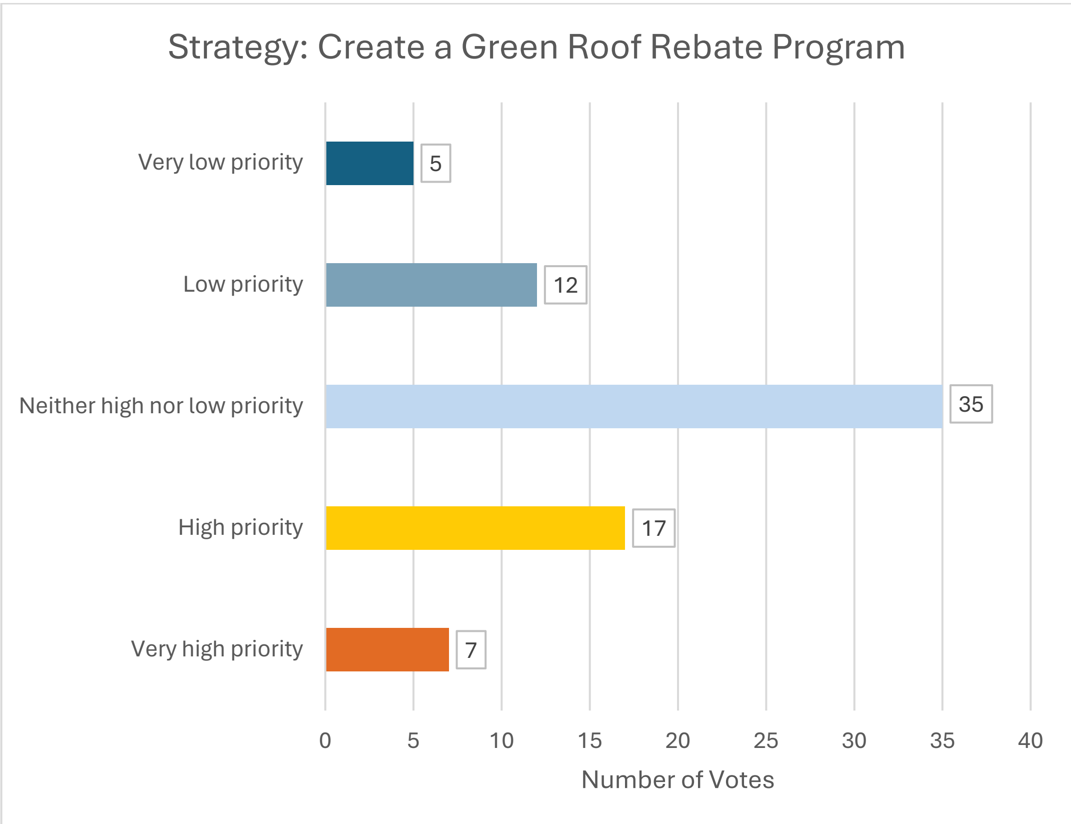
Strategy Prioritization

Following the public workshops, CMRPC drafted pollution reduction strategies related to the major climate polluting sectors. Then, CMRPC published a public survey and asked stakeholders to rank the strategies. The following charts display how survey respondents ranked the strategies for the Agriculture, Natural, and Working Lands sector.


Strategy: Establish an Urban Tree and Shrub Planting Program
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
29
21
18
7
2
0
5
10
15
20
25
30
35
40
Number of Votes


Strategy: Increase the Amount of Permanently Protected Land in MA and CT
Very high priority
High priority
Neither high nor low priority
Low priority
Very low priority
33
19
19
4
1
0
5
10
15
20
25
30
35
40
Number of Votes


Strategy: Assist Young Farmers to Purchase Land for Food Production
High priority
27
Very high priority
25
Neither high nor low priority
19
Very low priority
2
Low priority
2
0
5
10
15
20
25
30
35
40
Number of Votes


Strategy: Create a Green Roof Rebate Program
Very low priority
5
Low priority
12
Neither high nor low priority
35
High priority
17
Very high priority
7
0
5
10
15
20
25
30
35
40
Number of Votes

Overall, survey respondents prioritized three out of the four strategies CMRPC drafted for the Agriculture, Natural, and Working Lands sector. Conservation of existing forestland emerged as a top priority among survey respondents, followed by tree and shrub planting in urban areas, and then assisting young farmers with the purchase of farmland. Given the public feedback on the sectors, goals, and strategies and the GHG reductions associated with these strategies, urban tree and shrub planting and forestland conservation emerged as high priorities.

Agricultural, Natural and Working Lands: Goals, Strategies and Actions

Goals

1. Reduce/disincentivize land clearing and permanently protect land and water **- IMPORTANT.**
2. Increase carbon sequestration capacity **- IMPORTANT.**
3. Scale-up sustainable land use practices **- IMPORTANT.**
4. Improve livestock and manure management **- NOT AS IMPORTANT**

Table 32: Priority Agriculture, Natural & Working Lands Strategies

Goal	Strategy	Public Priority	GHG Reduction ($MTCO_2e$/year)	Municipal cost savings	Estimated Costs	LIDAC Benefits	Authority to Implement
1	1. Establish an urban tree and shrub planting program	Very High Priority	2,708	Medium	Medium	Medium	Local, Regional
2	2. Permanently protect forestland in MA and CT	Very High Priority	235	Medium	Low	Low	Local, Regional, Private
1 & 3	3. Assist young farmers to purchase local land for food production	High Priority	N/A	Low	Medium	Medium	Local, Regional, Private
3	4. Create green roof rebate program	Neutral	40	Low	Medium	Medium	Local, Regional, Private

Strategy 1. Establish an urban tree and shrub planting program

Overview

Specifically, this strategy would include establishing a grant program to support the planting and maintenance of native trees and shrubs in urban communities in the Worcester, MA-CT MSA. This grant program would focus on planting native species that require little maintenance, trees that may be better suited for the local environment, or trees capable of adapting to adverse conditions. This program would also prioritize areas within Justice 40 communities with little native tree and shrub coverage.

Based on the results from the pollution reduction strategies survey, the public rates this strategy as a very high priority. This valuation may be owed to urban trees and shrubs supplying numerous benefits. Their benefits include shade for people during extreme heat events, shade for homes and buildings that may reduce energy consumption, increased riparian vegetation to mitigate stormwater runoff, and increased access to green space. Furthermore, urban tree and shrub planting would increase the carbon sequestration capacity of our urban communities that may otherwise lack this opportunity to offset local GHG emissions.

Reduction Calculations

For the purposes of procuring quantified GHG reductions for this priority strategy, the CMRPC assumed that this program would plant an additional 2% tree cover in the Greater Worcester Region's seven disadvantaged communities, or LIDACs. If this program were implemented and an additional 2% tree canopy was planted and maintained within the seven LIDACs, the Region's carbon sequestration capacity would increase by 2,708 metric tons of carbon dioxide equivalent emissions per year (MT CO2e/year). This value was calculated by increasing the carbon sequestration capacity of the Worcester, MA-CT MSA's seven LIDACs by 2%.[cclxv]

Benefits and Challenges

CMRPC recognizes that various successful tree planting programs are currently available for Massachusetts and Connecticut communities. The Massachusetts Department of Conservation and Recreation (DCR) has a Greening the Gateway Cities Program (GGCP) that focuses on planting trees in the Commonwealth's gateway cities.[cclxvi] Massachusetts General Law (MGL) defines a gateway city as a municipality with a population greater than 35,000 and less than 250,000 with a median household income below the state average and a rate of educational attainment of a bachelor's degree or above that is below the state average.[cclxvii] Specifically, this program targets gateway cities with Environmental Justice (EJ) designations that have lower tree canopy, lower housing stock, higher wind speeds, and a larger renter population. The goal of this program is to plant an additional 5% of tree canopy in target neighborhoods. GGCP's tree planting implementation grants offer communities up to $150,000 to plant and maintain trees. Additionally, the GCCP acknowledges that expanding urban tree canopies decreases local energy consumption while improving water quality and invigorating local workforce opportunities.[cclxviii]

This strategy focuses on urban communities in the Greater Worcester Region, specifically the seven federally designated low-income and disadvantaged communities (LIDACs). The work the GGCP and similar programs have accomplished is monumental and may be used as an example. Given the maximum grant award for the GGCP, it is evident that increasing and maintaining urban canopies can cost municipalities a significant amount of money. Providing the Region's disadvantaged communities with additional avenues for expanding their urban canopies would allow for extensive municipal cost savings. However, going forward with this program, additional funding for the ongoing maintenance of these canopies must be considered. Nonetheless, this program would directly support the local workforce, from the purchase of tree cultivars from local growers to the hiring of residents to assist with tree planting and maintenance. This type of program could also serve as a training opportunity to youth, ensuring that LIDACs are equipped with a workforce that can sustain an urban canopy. Finally, increasing urban canopies would reap countless benefits on nearby residents, especially those with limited access to greenspace, those at risk of asthma or who are directly exposed to particulate matter, as well as those who suffer from high energy costs.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced GHG emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced healthcare costs
Risk of climate change impacts is reduced (i.e., heat, flooding)	Decreased morbidity incidence
Reduced air pollution (i.e., PM2.5)	Improved access to green space
Reduced noise pollution	Reduced energy consumption and associated costs
	Expanded ecosystem services
	Capacity building through local partnerships

LIDACs Impacted: All LIDACs Identified that are burdened by energy cost, lack of green space, projected flood risk, proximity to hazardous waste facilities, asthma, low-income, low median income, or unemployment.

Overall Priority and Authority to Implement

Overall, considering how the public prioritized the goals and strategies related to the agricultural, natural and working lands sector, as well as the associated greenhouse gas emissions reductions, this specific strategy is deemed a medium priority for the Greater Worcester GWPCAP. In terms of authority to implement, regional entities have a high authority to implement projects related to tree planting. Specifically, regional entities may partner with municipalities, such as LIDACs, to implement tree planting programs in accordance with any local bylaws and ordinances related to trees.

Adaptable & Tolerant Trees

Below is a table that lists trees that are native to the Eastern United States and well-suited to adverse environmental conditions. The column in this table labeled "tolerance" lists the types of hazards or environmental conditions each tree is evidenced to withstand. It is worth noting that no tree prefers an adverse environment, but some are more adaptable to certain conditions than others. This table also includes information about each tree's physical characteristics and preferred environmental conditions. Finally, the column labeled "notes" includes any other noteworthy characteristics or comments about each tree, including whether they are susceptible to pests. It is also worth noting that within urban environments, pests are generally not a major concern, as trees are not likely to be planted near dense natural environments. This table is not an exhaustive list of trees that are native to the Eastern U.S. that are especially suitable for an urban environment. These trees are merely examples of the types of trees that could be planted within the Greater Worcester Region's urban areas. The following table was developed using the University of Massachusetts' Department of Environmental Conservation's Guide titled *Planting for Resilience: Selecting Urban Trees in Massachusetts.*[cclxix]

Adaptable & Tolerant Trees – Native to Eastern United States

Tree	Conditions	Characteristics	Tolerance	Notes
Red Maple (*Acer Rubrum*)	**Light:** Full sun, partial shade **Moisture:** Tolerates occasional periods of dry and saturated soil	**Height:** 40-60' **Width:** 30-70' **Growth:** Medium - fast	Tolerates pollution, flooding, poor drainage	Over-planted in Eastern U.S. and susceptible to pests, such as Asian Longhorn Beetle (ALB)
Sugar Hackberry (*Celtis Laevigata)*	**Light:** Full sun, partial shade **Moisture:** Tolerates	**Height:** 60-80' **Width:** 50' **Growth:** Medium-fast	Tolerates drought, heat, salt, poor drainage, pollution, wind	Well-known for its adaptability to adverse environments and

	prolonged periods of dry soil			birds enjoy its fruit
Bald Cypress (*Taxodium distichum*)	**Light:** Full sun, partial shade **Moisture:** Tolerates occasional periods of dry and saturated soil	**Height:** 50-70' **Width:** 20-40' **Growth:** Slow-medium	Tolerates drought, flooding, salt, pollution, poor drainage, wind	May exhibit chlorosis when growing in alkaline soils
Arborvitae (*Thuja occidentalis*)	**Light:** Full sun, partial shade **Moisture:** Tolerates occasional periods of dry soil	**Height:** 40-60' **Width:** 10-15' **Growth:** Slow	Tolerates salt, pollution, poor drainage, shearing	May be susceptible to deer browse and branch breakage
American Elm (*Ulmus americana)*	**Light:** Full sun **Moisture:** Tolerates prolonged periods of dry soil and occasional periods of saturated soil	**Height:** 60-80' **Width:** 30-60' **Growth:** Medium-fast	Tolerates drought, flooding, salt, pollution, poor drainage	Highly adaptive but extremely susceptible to pests, so new cultivars are recommended

Source: University of Massachusetts Amherst, Department of Environmental Conservation Planting for Resilience: Selecting Urban Trees in Massachusetts[cclxx]

Strategy 2: Permanently protect forestland in MA and CT

Overview

This strategy would include developing an educational program for Worcester, MA-CT MSA landowners about the Chapter 61 Program and Conservation Restrictions in Massachusetts and Conservation Easements in Connecticut. This educational program would focus on how to implement these programs and promote their respective financial benefits. This educational program would have a flexible format, ranging from virtual webinars to in-person, pop-up workshops. Additionally, the local Regional Planning Agencies (RPAs) and Councils of Government (COGs) would offer technical assistance to communities that pursue relevant opportunities.

Based on the results from the pollution reduction strategies survey, the public rates this action as a very high priority. Again, this valuation may be owed to the various ecosystem services, public health and quality of life benefits that forestlands provide. The priority given to increasing awareness and implementation of forestland protections may also be attributed to the value of conserving land from development. Finally, it is evident that both municipalities and residents throughout the Worcester, MA-CT MSA are eager to learn more about existing incentives to protect forestland.

Reductions Calculations

For the purposes of procuring quantified GHG reductions for this priority action, the CMRPC assumed that this program would permanently protect 140 acres of forestland in MA and CT by 2035. Given this assumption, this action has the potential to mitigate 235 metric tons of carbon dioxide equivalent emissions per year (MTCO2e/year) by 2035. This was calculated by first determining the carbon dioxide sequestration value of one acre of forestland. Assuming these trees already exist and are included in the carbon sequestration calculation for this Plan, this carbon sequestration value is what would be maintained if this land was protected from development.

Benefits and Challenges

Establishing an educational program for communities within the Greater Worcester Region about forestland protections would also offer an opportunity to initiate an ongoing conversation about sustainable land use and sustainable land management among municipal officials, board and committee members, and the public. This may include sharing other avenues for protecting forestlands or sharing related resources, such as technical guidance on mitigating the impact of invasive species and pests. The Town of Harvard, Massachusetts, conducted a webinar in February 2024 about existing forestland protection programs, including the Massachusetts Chapter 61 Program and Conservation Restrictions.[cclxxi] This webinar and similar webinars offer the public an opportunity to learn about existing incentives for forestland protections, how to implement these protections, and allow resource and capacity sharing among experts and landowners.

Educational programs, such as webinar series or pop-up workshops, would not cost municipal or regional entities a significant amount of money to conduct. Additionally, if an initial pilot series were successful, increased funding may be more attainable to sustain such a program over the long-term. On the other hand, implementing forestland protections can save landowners a significant amount of money. For example, the Massachusetts Chapter 61 Program offers landowners an opportunity to reduce their property taxes by instituting a tax rate based on the current use of the property rather than the fair-market value or the development value[cclxxii]. Conservation Restrictions (CRs) in Massachusetts offer several financial benefits to landowners, such as tax deductions for charitable donations, income generation, and bargain sales.[cclxxiii] Similarly, Conservation Easements in Connecticut offer various financial incentives to landowners, including federal income tax deductions and estate tax benefits.[cclxxiv]

Protecting existing forestlands ensures that CJEST identified burdens such as lack of access to green space, projected flood risk, and high energy costs will not affect additional census tracts in the future due to forestland clearing. Furthermore, protecting forestlands allows for reduced asthma risk and increased income generation, as these incentives directly benefit landowners while sustaining local job opportunities in the forestry, conservation, and public works industries.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Community vulnerability to climate change impacts is reduced	Workforce development
Risk of climate change impacts is reduced (i.e., heat, flooding)	Capacity building through local partnerships
Reduced air pollution (i.e., PM2.5)	Access to green space
Reduced noise pollution	Reduced healthcare costs
Carbon sequestration capacity is maintained	Ecosystem services
	Reduced energy consumption and associated costs

LIDACs Impacted: All LIDACs Identified that are burdened by asthma, low-income, low-median income, energy cost, lack of green space, projected flood risk, or unemployment.

Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this action, increasing forestland protections within the Worcester, MA-CT is identified as a medium priority for this Plan. This priority action also directly aligns with both Massachusetts and Connecticut goals to conserve existing forestland. In terms of authority to implement, regional entities have a high authority to implement educational programs, such as webinar series and pop-up workshops. Regional entities could also partner with municipalities or municipal entities to coordinate educational workshops within specific communities, such as MA and CT environmental justice communities.

Strategy 3: Assist young farmers to purchase local land for food production

Overview

Specifically, this strategy would provide financial support to farmers between 18 and 35 for the purchase of farmland in the Greater Worcester Region. This action would prioritize applications that seek to purchase farmland near or within the Worcester, MA-CT MSA Environmental Justice communities. The goal of this program would be to increase access to healthy, local food while protecting prime agricultural land from development. Throughout this action's implementation, the importance of accepting Electronic Benefits Transfer (EBT) as well as sustainable land management practices would be promoted.

Most people who responded to the pollution reduction strategies survey indicated that supporting young farmers with the purchase of farmland is a high priority. This suggests that residents in the Greater Worcester Region support protecting the longevity of local food systems and increasing equitable access to healthy foods. This may also suggest that residents recognize the value in protecting local farmland from development while limiting the emissions associated with shipping food from elsewhere.

Reductions Calculations

For the purposes of attempting to procure quantified GHG reductions for this priority action, the CMRPC assumed that this program would provide financial support to Worcester, MA-CT MSA farmers that are between the ages of 18 and 35 to eventually establish an additional 10 acres of farmland in the Region. Although it has been demonstrated that the transportation of food accounts for 11% of GHG emissions associated with food systems, emissions vary widely based on food type, production process, and location.[cclxxv] Thus, additional analyses of emissions associated with agriculture would need to be conducted to determine a quantified GHG reduction value. Nonetheless, it may be assumed that local food production would decrease the GHG emissions associated with the transportation of food.

Benefits and Challenges

The purchase of farmland generally does not have an associated local cost, so a program to support it would not save a municipality money. However, when compared to the rest of the country, both Connecticut and Massachusetts have some of the highest farm real estate values. According to the United States Department of Agriculture (USDA) and the National Agriculture Statistics Service, the national average farm real estate value in 2022 was $3,800 per acre. In the same year, the Connecticut average farm real estate value was $13,700 per acre and the Massachusetts average farm real estate value was $15,200 per acre.[cclxxvi] This astounding variation in the price of prime agricultural soil throughout the country presents a formidable barrier to the longevity of local food systems in the Worcester, MA-CT MSA.

Invigorating local food production while safeguarding the future of our local food systems would directly supply the Region with healthy, local foods while also avoiding GHG emissions associated with importing food from elsewhere. Supporting young farmers in purchasing farmland would also avoid the development of prime agricultural soils. Establishing this program would also allow for an opportunity to promote sustainable and equitable practices to the next generation of farmers. These practices may include the value of accepting EBT (Electronic Benefits Transfer) or the cost- and emissions-reductions associated with different soil management practices, including fertilizer application. Additionally, establishing local farms in or near Environmental Justice communities would increase job opportunities for low-income and minoritized populations. These job opportunities would also serve as an opportunity to train the future farmers of the Region, with younger farmers leading them by example.

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced greenhouse gas emissions	Reduced healthcare costs
Community vulnerability to climate change impacts is reduced	Improved access to affordable and healthy local foods
Risk of climate change impacts is reduced (i.e., heat, flooding)	Workforce development
	Capacity building through local partnerships
	Improved access to green space
	Farmland protection

LIDACs Impacted: All LIDACs Identified that are burdened by unemployment, low-income, low median income, or lack of green space.

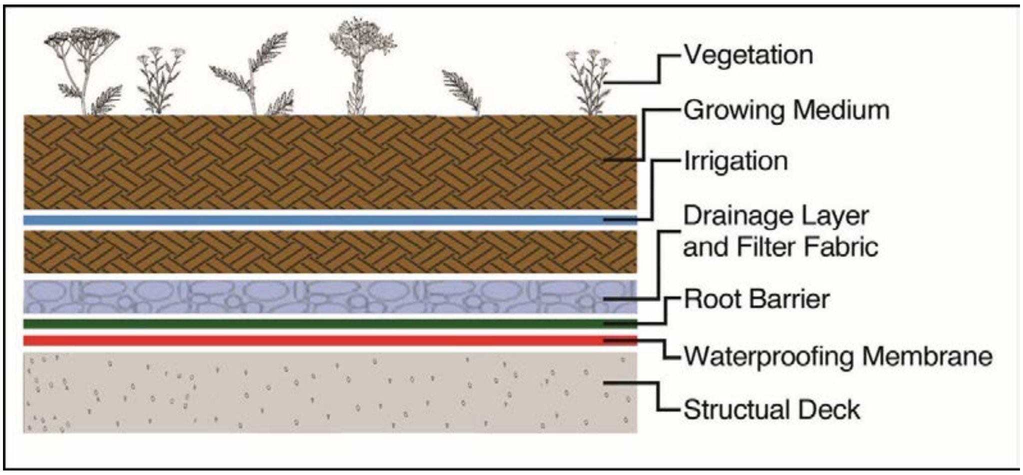
Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this strategy, developing a program to financially assist young farmers with the purchase of farmland is a low priority for the Greater Worcester Region GWPCAP. Regional entities have a high authority to implement a grant program to support young farmers in the purchase of farmland. This grant program would also offer a unique opportunity for both public and private partnerships, such as with local nonprofits and private farms.

Strategy 4: Create a green roof rebate program.

Overview

This strategy would include creating a green roof rebate program for Worcester, MA-CT MSA building owners to incentivize the implementation of green roof systems. A "green roof" is described as a contained green space on top of a building. A green roof system is an extension of a regular roof that involves at least a high-quality waterproofing layer, drainage and irrigation layers, and a vegetation layer.[cclxxvii] Creating a green roof rebate program would involve offering building owners a cost-reduction, either by a percent or fixed-amount, to lower the installment cost of these systems. This rebate program would prioritize buildings in low-income and disadvantaged communities and green roofs that grow native species.



Source: Green Roofs for Healthy Cities[cclxxviii]

Overall, most people who responded to the pollution reduction strategies survey indicated that developing a green roof rebate program is neither a high nor low priority. This may be attributed to their limited potential to substantially reduce greenhouse gas emissions. Nonetheless, green roofs are worth considering as they provide quality of life, public health, economic, and ecosystem benefits.

Reductions Calculations

For the purposes of procuring quantified GHG reductions for this strategy, the CMRPC assumed that this rebate program would support the implementation of 5,000 square feet of green roofs in the Region's seven LIDACs. Once achieved, the green roof rebate program would yield an emissions reduction of 40 metric tons of carbon dioxide equivalent emissions per year (MT CO2e/year). [cclxxix]

Benefits and Challenges

Although green roofs generally cost more than conventional roofs to install, they can be cost effective over their lifecycle. Green roofs can lower energy consumption and associated costs while providing stormwater mitigation. So, although conventional roofs may cost between $10 and $20 per square foot while green roofs can cost anywhere between $15 to $60 per square foot depending on the size of the roof, the life cycle of a green roof can be twice that of a conventional roof. The bulk of the cost associated with installing a green roof is due to the labor and equipment involved; the raw materials involved in installing a green roof are generally less expensive than that of a conventional roof. This is why the cost of installing a green roof generally decreases as the size of the green roof increases, providing an incentive for multi-family buildings and larger commercial buildings to consider green roof systems.[cclxxx]

Overall, a green roof rebate program would save municipalities money on the installation of green roof systems on municipal buildings while also offering long-term reductions in energy consumption. However, the remaining upfront cost of the green roof system combined with comparably minimal energy cost savings may make this rebate program less appealing to both public and private building owners compared to other energy efficiency programs for buildings.

Green roofs increase access to green space in urban environments while reintroducing aspects of the natural ecosystems that may support local wildlife. Supporting local wildlife, such as pollinators and birds, may result in cleaner air, water, and soil. Green roofs also offer an opportunity for waste diversion, such as using recycled materials in the growing medium or waterproofing layer. Overall, green roofs offer the revolutionary concept that urban environments can have plenty of green spaces. Green spaces provide public health and quality of life benefits, such as stress reduction, recreational opportunities, mitigated heat island effects, and aesthetic improvements.[cclxxxi]

Low-Income and Disadvantaged Communities Benefits Analysis and Workforce Development Opportunities:

Direct Benefits	*Co-Benefits*
Reduced greenhouse gas emissions	Workforce development
Community vulnerability to climate change impacts is reduced	Reduced healthcare costs
Reduced noise pollution	Decreased morbidity incidence
Risk of climate change impacts is reduced (i.e., heat, flooding)	Improved access to green space
Reduced air pollution (i.e., PM2.5)	Capacity building through local partnerships
	Reduced energy consumption and associated costs
	Expanded ecosystem services

LIDACs Impacted: All LIDACs Identified that are burdened by energy cost or lack of green space.

Overall Priority and Authority to Implement

Based on the public's feedback and the quantified greenhouse gas reductions associated with this strategy, developing a green roof rebate program is a low priority for the Greater Worcester GWPCAP. Although regional entities have the authority to implement grant programs related to climate resilience, regional entities have limited authority to implement a rebate program. To successfully develop and launch a regional green roof rebate program, private partnerships would need to be pursued and solidified. This may include a public-private partnership between a regional entity and a green roof installation company. This installer would also need to conduct assessments of public and private buildings before installing a green roof.

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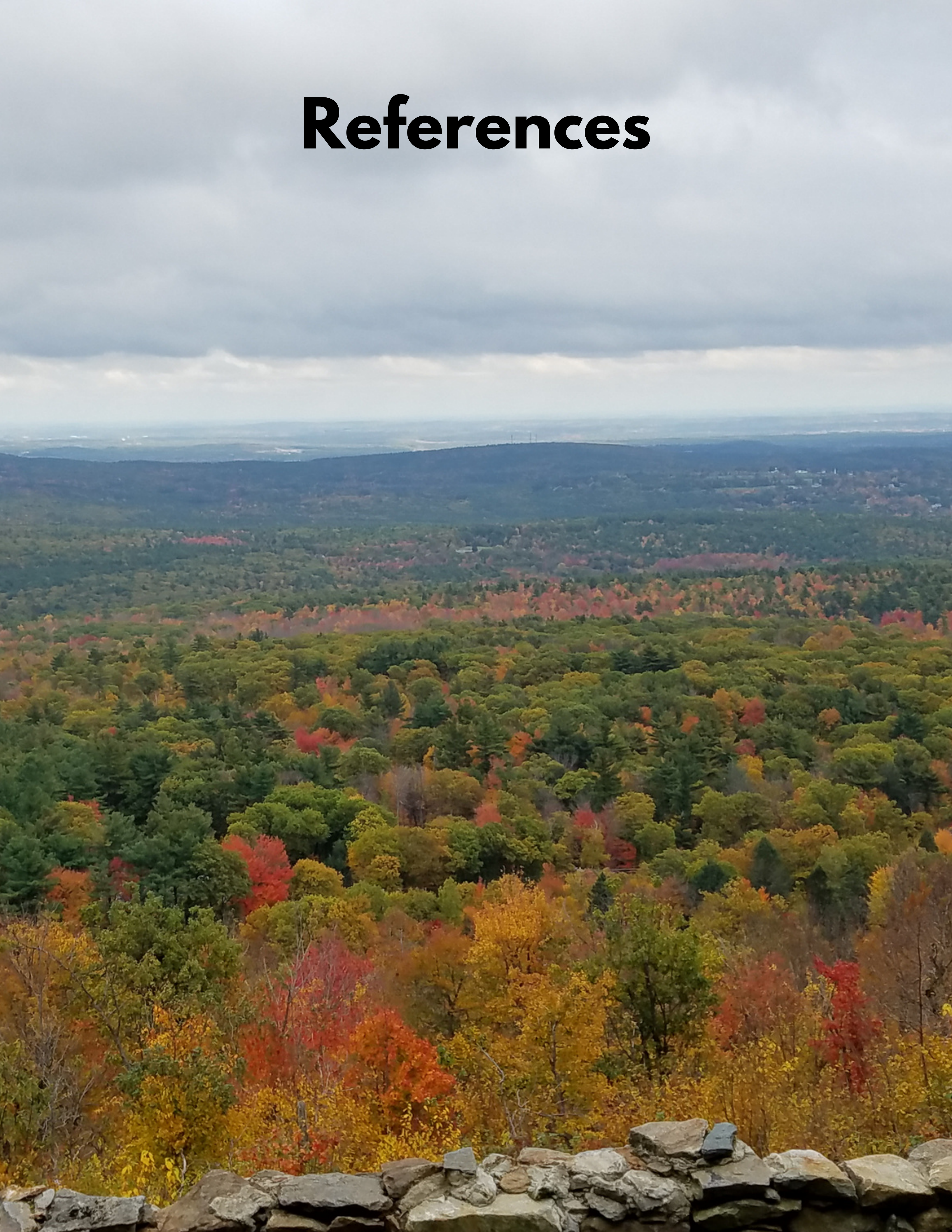

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Appendix

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APPENDIX A – GHG INVENTORY

Table A1: Community-wide Emissions Summary by Sector, Subsector, Source, Scope & Gas									
Sector	**Subsector**	**Source**	**Scope**	**Carbon Dioxide Emissions (MT CO2)**	**Methane Emissions (MT CH4)**	**Nitrous Oxide Emissions (MT N2O)**	**Carbon Dioxide Equivalent Emissions (MT CO2e)**	**Carbon Dioxide Equivalent Emissions (MMT CO2e)**	**Percent of Total**
Stationary Energy & Electricity	Residential Buildings	Electricity	2	577,471.89	56.60	7.75	581,109.23	0.58	5%
		Electricity T&D Losses	3	28,737.96	3.17	0.30	28,905.72	0.03	0%
		Fuel Oil	1	980,768.39	39.78	7.96	983,990.77	0.98	9%
		Natural Gas	1	504,253.72			504,253.72	0.50	5%
		Nat. Gas. Dist. Losses	1	52.25	4,880.54		136,707.40	0.14	1%
	Commercial & Institutional Buildings & Manufacturing Industries	Electricity	2	836,328.42	79.41	10.89	841,437.47	0.84	8%
		Electricity T&D Losses	3	42,271.00	4.35	0.45	42,512.80	0.04	0%
		Fuel Oil	1	249,155.39	9.34	1.86	249,908.49	0.25	2%
		Natural Gas	1	955,156.22			955,156.22	0.96	9%
		Nat. Gas. Dist. Losses	1	98.98	9,244.71		258,950.83	0.26	2%
		Off-Road (Various Fuels)	1	186,148.35	103.05		189,033.75	0.19	2%
	Construction	Off-Road (Various Fuels)	1	157,624.09	6.76		157,813.37	0.16	1%
Transportation	On Road	Diesel	1	551,790.50	27.26	19.48	557,715.46	0.56	5%
		Electricity	2	1,313.32	0.14	0.02	1,322.11	0.00	0%
		Electricity T&D Losses	3	67.29	0.01	0.00	67.72	0.00	0%
		Gasoline	1	5,004,073.90	247.20	176.64	5,057,806.14	5.06	46%
	Rail	Diesel	1	10,753.86	0.53	0.38	10,869.33	0.01	0%
Waste	Solid Waste Disposal	Methane Commitment	1	-	9,527.97	-	266,783.19	0.27	2%
	Biological Treatment of Waste	Direct Emissions	1	-	16.03	1.20	767.61	0.00	0%
	Incineration and Open Burning	Incineration	1	7,233.48	0.06	14.16	10,987.61	0.01	0%
	Wastewater Treatment and Discharge	Effluent	1	-	2,976.14	68.27	101,423.68	0.10	1%
	Solid Waste Disposal	Methane Commitment	3	-	2,610.11	-	73,083.15	0.07	1%
	Incineration and Open Burning	Incineration	3	1,981.55	0.02	3.88	3,009.97	0.00	0%
Agriculture	Fertilizer	Fertilizer Application	1			129.12	34,216.50	0.03	0%
Natural & Working Lands	Carbon Sequestration	Urban Forestry	-	(1,993,374.84)	0	0	(1,993,374.84)	(1.99)	
Gross Emissions				10,095,280.58	29,833.16	442.35	**11,047,832**	**11.05**	**100%**
Net Emissions				8,101,905.74	29,833.16	442.35	**9,054,457**	**9.05**	

Table A2: Community-wide Emissions Summary by Sector & Subsector

Sector	Subsector	MTCO2e	MMTCO2e
Stationary Energy & Electricity	Residential Buildings	2,234,967	2.23
	C/I Buildings & Manufacturing Industries	2,537,000	2.54
	Construction	157,813	0.16
Transportation	On Road	5,616,911	5.62
	Rail	10,869	0.01
Waste	Waste	456,055	0.46
Agriculture	Fertilizer	34,217	0.03
Natural & Working Lands	Carbon Sequestration	(1,993,375)	(1.99)

Table A3: Community-wide Emissions Summary by Sector

Sector	MTCO2e	MMTCO2e	Percent
Stationary Energy	3,435,815	3.4	31%
Electricity	1,493,965	1.5	14%
Transportation	5,627,781	5.6	51%
Waste	456,055	0.5	4%
Agriculture	34,217	0.03	0%
Natural & Working Lands	(1,993,375)	(2.0)	
Gross Emissions	**11,047,832**	**11.0**	**100%**
Net Emissions	**9,054,457**	**9.1**	

Table A4: Community-wide Summary of Building Energy Use by Sector and Source

Subsector	Source	Emissions (MTCO2e)	% of Total Energy Emissions
Residential Buildings	Res. Electricity	610,015	5.5%
	Res. Fuel Oil	983,991	8.9%
	Res. Natural Gas	640,961	5.8%
Commercial & Institutional Buildings and Facilities + Manufacturing Industries*	Comm. & Man. Electricity	883,950	8.0%
	Comm. & Man. Fuel Oil	249,908	2.3%
	Comm. & Man. Natural Gas	1,214,107	11.0%
All Buildings	Electricity	1,493,965	13.5%
	Fuel Oil	1,233,899	11.2%
	Natural Gas	1,855,068	16.8%

Table A5: Community-wide Emissions Summary by Sector and Subsector

Sector	Subsector	Total Emissions (MT CO2e)	% of Total Emissions	% of Emissions in Respective Sector
Stationary Energy & Electricity	Residential Buildings	2,234,967	20.2%	45.3%
	C&I Buildings & Manufacturing Industries	2,537,000	23.0%	51.5%
	Construction	157,813	1.4%	3.2%
Transportation	MA Passenger Vehicles	2,890,303	26.2%	51.4%
	MA Commercial Vehicles	359,433	3.3%	6.4%
	MA State & Municipal Vehicles	22,846	0.2%	0.4%
	CT Vehicles	2,344,328	21.2%	41.7%
	MBTA Commuter Rail	10,869	0.1%	0.2%
Waste	Solid Waste Disposal	339,866	3.1%	74.5%
	Biological Treatment of Waste	768	0.01%	0.2%
	Incineration and Open Burning	13,998	0.1%	3.1%
	Wastewater Treatment and Discharge	101,424	0.9%	22.2%
Agriculture	Commercial Fertilizer	34,217	0.3%	100%
Natural & Working Lands	Carbon Sequestration	(1,993,374.84)		
	Gross Emissions	**11,047,832**	**100%**	
	Net Emissions	**9,054,457**		

APPENDIX B – GHG METHODOLOGY DESCRIPTION AND SUMMARY BY SECTOR

1.1 Summary Overview

The year 2017 was used for this baseline GHG emissions inventory assessment. Five key sectors were evaluated to estimate emissions: stationary energy & electricity, transportation, waste, agriculture, and natural & working lands. Descriptions of the type of data included for each of these sectors is included in Table 1.

Table 1. Community-wide Emissions Sectors and Subsectors

Sector	Subsector	Source
Stationary Energy & Electricity	Residential Buildings	Electricity
		Electricity T&D Losses
		Fuel Oil
		Natural Gas
		Nat. Gas. Dist. Losses
	Commercial & Institutional Buildings & Manufacturing Industries	Electricity
		Electricity T&D Losses
		Fuel Oil
		Natural Gas
		Nat. Gas. Dist. Losses
		Off-Road (Various Fuels)
	Construction	Off-Road (Various Fuels)
Transportation	On-road (and MBTA Ferries)	CNG
		Diesel
		Electricity
		Electricity T&D Losses
		Gasoline
	Rail	Diesel
		Electricity
		Electricity T&D Losses
Waste	Solid Waste Disposal	Methane Commitment
	Biological Treatment of Waste	Direct Emissions
	Incineration and Open Burning	Incineration
	Wastewater Treatment and Discharge	Effluent
	Solid Waste Disposal	Methane Commitment
	Incineration and Open Burning	Incineration
Agriculture	Fertilizer	Fertilizer Application
Natural & Working Lands	Carbon Sequestration	Urban Forestry

1.2 Data Summaries by Sector

1.2.1 Electricity & Stationary Energy

Electricity

Data for the subsector sources were collected from publicly available state and federal datasets, as identified in Table 2.

Table 2. Electricity Subsector Sources

Sector	Subsector	Source	Dataset	Description
Electricity	Residential, Commercial, Institutional Buildings	Electricity Usage by Community (MA)	MassSave Data[1]	MassSave electricity data by community for 2017. Usage data is calendarized to represent actual usage (not billing) in a given month or year.
		Electricity Usage by Community (CT)	Energize CT[2]	Statewide electricity data for residential and commercial usage for 2017.
		Municipal Light Departments (MA)	MA DPU[3] & MA DEP[4]	Municipal Light Plant annual returns from the MA Department of Public Utilities (DPU). This data source fills the gaps from Mass Save where it says "municipal."
		Community Choice Aggregation (MA)	MA DPU[5]	Municipal aggregation annual reports from MA DPU, containing usage and program.
		Electricity T&D Losses (MA & CT)	EIA[6]	Transmission and distribution (T&D) losses.

The methodology used to calculate CO_2e emissions (MMT) for the electricity sector was based on the MAPC GHG Emissions Inventory Tool. The Tool's detailed methodology document contains further details as necessary for review.[7] There were few variations made to the methodology from the MAPC Tool, in order to most accurately represent the MSA. They included the following:

- New England eGRID emissions factors were used for CT electricity calculations.
- The CT portion of the MSA does not have any community choice aggregation or municipal utilities.
- CT Transmission & Distribution Grid Loss Factor (%) was determined based the 2017 EIA CT electricity profile and calculated separately than the MA Transmission & Distribution Grid Loss Factor. The calculation results are shown in Table 3.

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1 https://www.masssavedata.com/public/home
2 https://www.ctenergydashboard.com/CEC/CEC_ConsumptionData.aspx
3 https://www.mass.gov/info-details/find-an-mlp-annual-return
4 https://www.mass.gov/doc/2017-summary-massachusetts-ghg-emissions-reports-for-retail-sellers-of-electricity/download
5 https://www.mass.gov/info-details/municipal-aggregation-annual-reports#2017-annual-reports-
6 https://www.eia.gov/electricity/data.php
7 https://www.mapc.org/resource-library/community-ghg-inventory-resources/

Table 3. Electricity Transmission & Distribution Grid Loss Factor for CT

Total Disposition (MWh)	Direct Use (MWh)	Total Disposition Excluding Direct Use (MWh)	Estimated Losses (MWh)	Grid Loss Factor (%)
35,089,883	981,617	34,108,266	1,530,529	4.49%

The results of the electricity emissions calculations are shown in Table 4.

Table 4. Community-wide Electricity CO_2e Emissions

Sector	Subsector	Source	Carbon Dioxide Equivalent Emissions (MMT CO_2e)	Percent of Total Community-wide Emissions
Electricity	Residential Buildings	Electricity	0.58	5.3%
		Electricity T&D Losses	0.03	0.3%
	Commercial & Institutional Buildings and Manufacturing Industries	Electricity	0.84	7.6%
		Electricity T&D Losses	0.04	0.4%

Stationary Energy

Data for the subsector sources were collected from publicly available state and federal datasets, as identified in Table 5.

Table 5. Stationary Energy Sources and Datasets

Sector	State	Source	Dataset	Description
Stationary Energy	**MA & CT**	*Off Road County Total and Manufacturing Employment*	US Census	US Census Data from Table CB1700CBP All Sectors: County Business Patterns by Legal Form of Organization and Employment Size Class for U.S., States, and Selected Geographics: 2017. This is county level employment data for all sectors and the manufacturing sector.
Stationary Energy	**MA & CT**	*Off Road County and City/Town Total and Manufacturing Employment*	US Census	US Census Data from Table S2405 Industry by Occupation for the Civilian Employed Population 16 Years and Over, 2017 5 year estimate. This source has county and city/town level data for total employment and manufacturing employment.
Stationary Energy	**CT**	*Natural Gas by town*	Energize CT	Natural gas consumption in units of ccf by town for residential and commercial

Sector	State	Source	Dataset	Description
Stationary Energy	**MA**	*Natural Gas usage by town*	MassSave	MassSave statewide Natural Gas data by community or county for 2017. Usage data is calendarized to represent actual usage (not billing) in a given month or year.
Stationary Energy	**CT**	*EPA MOVES off-road transportation emissions*	EPA MOVES	This data source will fill the gaps from DataCommon where there was no CT data for off-road transportation emissions by county
Stationary Energy	**MA**	*County Off-Road Transportation Emissions CO_2 & CH_4*	DataCommon	County off road transportation emissions
Stationary Energy	**MA**	*Square Feet of Developed Open Space*	DataCommon	Open space off road county and municipality landscaped area emissions
Stationary Energy	**MA**	*Commercial and Industrial Heating Oil*	EOLWD	Massachusetts Executive Office of Labor and Workforce Development (EOLWD) Employment and Wages (ES-202) annual report data, all ownership types, with "Total, All Industries", "Category and all sub-categories". County level data was used and communities that are not in the MSA were subtracted from county totals.
Stationary Energy	**CT**	*Square Feet of Developed Open Space*	CT High Res Landcover (NOAA CCAP)[8]	Square feet of developed open space by town in CT
Stationary Energy	**CT**	*Commercial and Industrial Heating Oil*	CT Dept. of Labor	Annual Census of Employment & Wages by County[9]
Stationary Energy	**MA & CT**	*Municipal Heating Oil*	EIA	Fuel oil consumption and conditional energy intensity by census region from the Energy Information Administration (EIA) 2018 Commercial Buildings Energy Consumption Survey (CBECS) Data. 156 million gallons of fuel oil consumed by local government owned buildings in the Northeast which includes the 6 New England states, NY, NJ, and PA. This data was used with 2017 Census data for Number of Municipalities in each state. The number of municipalities in the MSA represents 2.6% of all municipalities in the 9 states and this percentage was multiplied by the total gallons of fuel oil.

[8] CT High Res Land Cover (NOAA CCAP) (arcgis.com)
[9] Labor Market Information - Windham County (state.ct.us)

The methodology used to calculate CO_2e emissions (MMT) for the stationary energy sector was based on the MAPC GHG Emissions Inventory Tool. The Tool's detailed methodology document contains further details as necessary for review.[10] There were few variations made to the methodology from the MAPC Tool, in order to most accurately represent the MSA. They included the following:

- To determine CT Fuel Oil consumption, the Massachusetts values were scaled based on details in Table 6.

Table 6. Scaling for the Fuel Oil Adjustment Ratio for CT[11]

Scale	Fuel oil consumption per household using fuel oil (gallons)
US	507
MA	619
CT	629
Adjustment Ratio	**1.54**

Electricity & Stationary Energy Summary

Results of the electricity and stationary energy consumption for the MSA are described in Tables 7 & 8.

Table 7. SUMMARY Community-wide Electricity & Stationary Energy Usage and Emissions

Type	kWh	Percent
Investor Owned Utilities	5,424,338,448	82.3%
Community Choice Aggregation	67,711,407	1.0%
Municipal Utilities	765,372,856	11.6%
T&D Losses (all)	334,230,117	5.1%

[10] https://www.mapc.org/resource-library/community-ghg-inventory-resources/
[11] https://experience.arcgis.com/experience/cbf6875974554a74823232f84f563253

Table 8. SUMMARY Community-wide Summary of Building Energy Use by Subsector & Source

Subsector	Source	Emissions ($MTCO_2e$)	% of Total Energy Emissions
Residential Buildings	Res. Electricity	610,015	13.3%
	Res. Fuel Oil	983,991	21.5%
	Res. Natural Gas	640,961	14.0%
Commercial & Institutional Buildings and Facilities & Manufacturing Industries*	Comm. & Man. Electricity	883,950	19.3%
	Comm. & Man. Fuel Oil	249,908	5.5%
	Comm. & Man. Natural Gas	1,214,107	26.5%
All Buildings	Electricity	1,493,965	32.6%
	Fuel Oil	1,233,899	26.9%
	Natural Gas	1,855,068	40.5%

*The above energy consumption and emissions data excludes electricity transmission and distribution losses associated with electricity and natural gas.

1.2.2 Transportation

The methodology used to calculate CO_2e emissions (MMT) for the transportation sector was based on the MAPC GHG Emissions Inventory Tool. The Tool's detailed methodology document contains further details as necessary for review.[12] There were few variations made to the methodology from the MAPC Tool, in order to most accurately represent the MSA. They included the following:

- The MAPC Tool recommends using 2014 MA Vehicle Census Data for on-road vehicles, however, more recent data has since been released and was used to interpolate values for 2017.
- CT on-road vehicle data was sourced from national Department of Transportation (DOT) and Department of Energy (DOE) resources, as described in the Table 9. The data was not available by the same fuel types as MA data.
- Data pertaining to public buses were likely already included in both the MA and CT datasets. RTAs were contacted to obtain a better estimate of fuel associated with public transportation, but limited data was received and therefore public transportation was not called out specially from other commercial vehicles.

Table 9. Transportation Sources and Datasets

Sector	State	Source	Dataset	Description
Transportation	**MA**	*On-road vehicles*	MA Vehicle census (interpolated by MAPC to obtain 2017 data)	Residential, commercial, state, and municipal vehicle fuel usage by fuel type (gasoline, diesel, flexfuel, hybrid, electric)

[12] https://www.mapc.org/resource-library/community-ghg-inventory-resources/

Sector	State	Source	Dataset	Description
Transportation	**CT**	*On-road vehicles*	DOT State Statistical Abstracts,[13] DOT Highway Statistics Motor Fuel Use[14]	Registered vehicles, vehicle miles traveled, and fuel usage (gasoline and special fuels) by vehicle type (automobile, buses, trucks, motorcycles)
Transportation	**CT**	*Electric vehicles*	DEEP EV Registration Factsheet[15]	Electric vehicles registered in CT by town and by year
Transportation	**MA**	*MBTA commuter rail*	MBTA Data APTA Metrics	Quantities of diesel

Refer to Table 12 & 13 for emissions by transportation subsector.

1.2.3 Waste

Waste emissions were calculated based on the following four subsectors: Solid Waste Disposal, Biological Treatment of Waste, Incineration and Open Burning, and Wastewater Treatment and Discharge.

The methodology used to calculate CO_2e emissions (MMT) for the waste sector was based on the MAPC GHG Emissions Inventory Tool. The Tool's detailed methodology document contains further details as necessary for review.[16] There were few variations made to the methodology from the MAPC Tool, in order to most accurately represent the MSA. They included the following:

- Disposal locations of waste by town are not tracked. Therefore, waste crossing in or out of the MSA boundary was unable to be determined. Consequently, it was assumed that waste categorized as net exports were Scope 3, and in-state disposal were Scope 1.

- Mass of solid waste disposed by composting and anaerobic digestion for the MSA was estimated using the EPA dataset described in Table 10 for MA. The tons of waste composted

[13] https://explore.dot.gov/views/StateStatisticalAbstracts_16699101653250/DashboardALT?%3Aembed=y&%3Aiid=1&%3AisGuestRedirectFromVizportal=y
[14] https://www.fhwa.dot.gov/policyinformation/statistics/2017/mf21.cfm
[15] https://portal.ct.gov/-/media/DEEP/air/mobile/CHEAPR/EV-Reg-Fact-Sheet.pdf
[16] https://www.mapc.org/resource-library/community-ghg-inventory-resources/

in CT was obtained directly from CT Department of Energy & Environmental Protection (DEEP).

Table 10. Waste Sources and Datasets

Sector	State	Source	Dataset	Description
Waste	MA	Solid Waste Disposal	MassDEP[17]	Tons landfilled waste
Waste	MA	Biological Treatment of Waste	EPA[18]	Composting & anaerobic digestion
Waste	MA	Incineration and Open Burning	MassDEP[16]	Tons incinerated waste
Waste	CT	Solid Waste Disposal	CT DEEP [19] (via Brenna Toman)	Tons landfilled waste
Waste	CT	Biological Treatment of Waste	CT DEEP (via Brenna Toman)	Composting
Waste	CT	Incineration and Open Burning	CT DEEP (via Brenna Toman)	Tons incinerated waste
Waste	MA & CT	Wastewater Treatment and Discharge	US Census, MWRA (contacted directly)	Percent of MSA population served by WWTPs with anaerobic digestion and co-generation systems and other WWTPs

Refer to Table 12 & 13 for emissions by waste subsector.

1.2.4 Agriculture

The MAPC GHG Emissions Inventory Tool does not include agriculture and it was therefore added to this regional GHG inventory to account for emissions associated with agricultural fertilizers. For this sector, the EPA Local Greenhouse Gas Inventory Tool was used to determine methodology.

Fertilizer application to lands within the MSA contribute to GHG emissions from the volatilization into the air in the form of nitrous oxide (N_2O). The portion of the quantities of commercial fertilizer purchased in MA and CT were allocated to the MSA by using the percent of farms or acres of farms by county. In counties that are not fully within the MSA, a portion was allocated based on land area.

Table 11. Agriculture Sources and Datasets

Sector	State	Source	Dataset	Description

[17] https://www.mass.gov/doc/2017-solid-waste-data-update/download
[18] https://www.epa.gov/sites/default/files/2020-11/documents/2018_wasted_food_report.pdf (pg. 58 & 59)
[19] https://portal.ct.gov/DEEP/Reduce-Reuse-Recycle/Data/Solid-Waste--Recycling-Data

Agriculture	**MA & CT**	**Commercial fertilizer usage**	EPA[20]	Commercial fertilizer purchased in 2017
			State Census of Agriculture (UMass[21], USDA[22])	Land in farms in 2017

1.2.5 Natural and Working Lands

The MAPC GHG Emissions Inventory Tool does not include natural and working lands and it was therefore added to this regional GHG inventory to account for carbon sequestration from trees. The OurTrees tool from i-Tree[23] was used to obtain the annual carbon sequestered and CO_2 equivalent in units of tons for each community in the MSA. The value for all communities was summed to get the total annual carbon sequestration for the region. This tool also provides air pollution removal for carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$.

1.3 Further GHG Inventory Detailed Results

Table 12. Community-wide Emissions Summary by Sector

Sector	$MTCO_2e$	$MMTCO_2e$	Percent
Stationary Energy	3,435,815	3.4	31%
Electricity	1,493,965	1.5	14%
Transportation	5,627,781	5.6	51%
Waste	456,055	0.5	4%
Agriculture	34,217	0.03	0%
Natural & Working Lands	(1,993,375)	(2.0)	
Gross Emissions	**11,047,832**	**11.0**	**100%**
Net Emissions	**9,054,457**	**9.1**	

Table 9. Community-wide Emissions Summary by Sector and Subsector

Sector	Subsector	Total Emissions (MT CO_2e)	% of Total Emissions	% of Emissions in Respective Sector
Stationary Energy & Electricity	Residential Buildings	2,234,967	20.2%	45.3%
	C&I Buildings & Manufacturing Industries	2,537,000	23.0%	51.5%
	Construction	157,813	1.4%	3.2%
Transportation	MA Passenger Vehicles	2,890,303	26.2%	51.4%
	MA Commercial Vehicles	359,433	3.3%	6.4%
	MA State & Municipal Vehicles	22,846	0.2%	0.4%

[20] https://www.epa.gov/nutrientpollution/commercial-fertilizer-purchased
[21] https://ag.umass.edu/resources/massachusetts-agricultural-data/acres-land-in-farms
[22] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Connecticut/st09_2_0008_0008.pdf
[23] https://ourtrees.itreetools.org/#/

	CT Vehicles	2,344,328	21.2%	41.7%
	MBTA Commuter Rail	10,869	0.1%	0.2%
Waste	Solid Waste Disposal	339,866	3.1%	74.5%
	Biological Treatment of Waste	768	0.01%	0.2%
	Incineration and Open Burning	13,998	0.1%	3.1%
	Wastewater Treatment and Discharge	101,424	0.9%	22.2%
Agriculture	Commercial Fertilizer	34,217	0.3%	100%
Natural & Working Lands	Carbon Sequestration	(1,993,374.84)		
All Sectors & Subsectors (Gross Emissions)		**9,054,457**		

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APPENDIX C – CO-POLLUTANT BASELINE INVENTORY

A baseline co-pollutants emissions inventory year has been conducted for 2017. To determine an estimate of the Criteria Air Pollutants (CAPs) and Hazardous Air Pollutants (HAPs) emitted, data from the 2017 National Emissions Inventory (NEI) database was analyzed.[1] Quantifying these CAP and HAP sources show a more holistic picture of the total air pollutants emitted by and consequently impacting the MSA. The general methodology for determining the quantity of CAP and HAP emissions in 2017 consisted of downloading county specific data and allocating a percentage of the co-pollutant emissions based on population. The following sectors were assessed for this inventory, as they relate to the sectors quantified in the GHG inventory methodology:

- Agriculture - Fertilizer Application
- Fuel Comb - Comm/Institutional - Natural Gas
- Fuel Comb - Comm/Institutional - Oil
- Fuel Comb - Electric Generation - Natural Gas
- Fuel Comb - Electric Generation - Oil
- Fuel Comb - Industrial Boilers, ICEs - Natural Gas
- Fuel Comb - Industrial Boilers, ICEs - Oil
- Fuel Comb - Residential - Natural Gas
- Fuel Comb - Residential - Oil
- Industrial Processes - Oil & Gas Production
- Mobile - Locomotives
- Mobile - Non-Road Equipment - Diesel
- Mobile - Non-Road Equipment - Gasoline
- Mobile - On-Road Diesel Heavy Duty Vehicles
- Mobile - On-Road Diesel Light Duty Vehicles
- Mobile - On-Road non-Diesel Heavy Duty Vehicles
- Mobile - On-Road non-Diesel Light Duty Vehicles
- Waste Disposal

CAPs emissions estimated as part of this co-pollutants inventory include the following:

- Ammonia
- Carbon Monoxide
- Elemental Carbon portion of PM2.5-PRI
- Lead
- Organic Carbon portion of PM2.5-PRI
- PM10 Primary (Filt + Cond)
- PM2.5 Primary (Filt + Cond)
- Remaining PMFINE portion of PM2.5-PRI
- Sulfur Dioxide
- Volatile Organic Compounds

Over 150 HAPs were included in the quantification of HAP emissions in this inventory.

Co-Pollutant Baseline Emissions Inventory for 2017	
Criteria Air Pollutants	**Hazardous Air Pollutants**
79,317 metric tons	**1,615 metric tons**

[1] https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data