Office of Climate Innovation & Resilience and Department of Transportation

Massachusetts Priority Climate Action Plan

Submitted to the Environmental Protection Agency



March 2024

Acknowledgements

This Priority Climate Action Plan is based on the collaborative effort of many groups from across Massachusetts including dedicated staff from state agencies, municipalities, regional planning agencies, community-based organizations including those centered on environmental justice and labor, and many individuals. This Plan also depends upon decades of climate-related planning and analytic work centered in the Massachusetts Department of Environmental Protection. Finally, this Plan supplements, but does not replace, the work and collaboration embodied in the Massachusetts Clean Energy and Climate Plans published in 2022 and led by the staff of the Executive Office of Energy and Environmental Affairs and its associated agencies.

Definitions and Acronyms

Acronyms

BIL	Bipartisan Infrastructure Law
CCAP	Comprehensive Climate Action Plan
CECP	Clean Energy and Climate Plan
CEJST	Climate and Economic Justice Screening Tool
CPRG	Climate Pollution Reduction Grant
DEP	Massachusetts Department of Environmental Protection
DOE	Massachusetts Department of Energy
DOER	Massachusetts Department of Energy Resources
EEA	Massachusetts Executive Office of Energy and Environmental Affairs
EJ	Environmental Justice
EPA	Environmental Protection Agency
EV	Electric Vehicles
GHG	Greenhouse Gas
GWSA	Global Warming Solution Act
HFC	Hydrofluorocarbons
HVAC	Heating, Ventilation, and Air Conditioning
IRA	Inflation Reduction Act
LIDAC	Low Income Disadvantaged Communities
$MMTCO_2e$	Million Metric Tons of Carbon Dioxide Equivalent
MSA	Metropolitan Statistical Area
NWL	Natural and Working Lands
PCAP	Priority Climate Action Plan
PFC	Perfluorocarbons
RPA	Regional Planning Agencies
VMT	Vehicle Miles Traveled
ZEV	Zero Emission Vehicle

Definitions

Carbon Neutral: The emissions of carbon dioxide are balanced with their sequestration. This is done through implementing energy efficiency measures, the use of renewable energy, and offsetting emissions.

Clean Energy: The production of energy to be used for electricity or heat through renewable energy sources that do not emit carbon into the air. These sources include solar, wind, water, and geothermal to name a few.

Clean Energy Climate Plans (CECP): Massachusetts' comprehensive plans Massachusetts' comprehensive plans detailing the actions to achieve emissions limits by 2025, 2030 and 2050 using sector-specific sub limits to reduce GHG emissions by 50 percent in 2030 from 1990 levels and achieve Net Zero emissions limits in 2050.

Climate: Long term weather pattern over an extended period of time at a specific location. Described by statistics, such as means and extremes of temperature, precipitation, and other variables, and by the intensity, frequency, and duration of weather events.

Climate and Economic Justice Screening Tool (CEJST): A mapping tool developed by the Council on Environmental Quality that identifies disadvantaged communities which are overburdened and underserved.

Climate Change: A long term shift in the climate, including temperatures and weather patterns. Climate change can be caused by either natural changes in the environment or through human activities due to the burning of fossil fuels.

Climate Pollution Reduction Grant (CPRG) Program: The Climate Pollution Reduction Grants (CPRG) program provides $5 billion in grants to states, local governments, tribes, and territories to develop and implement ambitious plans for reducing greenhouse gas emissions and other harmful air pollution.

Co-benefits: Refers to the multi-faceted benefits that occur when climate actions are taken. These benefits can include cost savings, improved air quality and associated improvements in health, increased greenery and mental health benefits, community engagement, and new jobs.

Comprehensive Climate Action Plan (CCAP): Following the PCAP, planning grant recipients must evaluate the extent to which any GHG reduction measures in the CCAP will deliver co-pollutant emissions reductions and other benefits to LIDACs.

Fossil Fuels: A type of fuel made from decomposing plants and animals deep in the earth's crust that can be burned for energy. Natural gas, oil, and coal are all fossil fuels.

Greenhouse Gases (GHG): Gases that trap heat in the atmosphere. These gases include carbon dioxide, nitrous oxides, methane, and fluorinated gases. The Earth needs these gases in the atmosphere to trap heat and make the planet habitable, but the excess of GHG emissions leads to increased levels of heating resulting in a changing climate.

Mitigation: Prevention or intervention of climate harming activities. This includes reducing emissions and stabilizing levels of greenhouse gases in the atmosphere.

Particulate Matter: PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. PM causes severe health issues as well as contributing to environmental degradation.

Priority Climate Action Plan (PCAP): A document that is developed as part of a U.S. Environmental Protection Agency (EPA) Climate Pollution Reduction Grant (CPRG) Phase I Planning Grant, identifying priority measures for reducing greenhouse gas (GHG) emissions and achieving other goals of the CPRG program, as well as a Low Income and Disadvantaged Community (LIDAC) benefits analysis.

Resilience: The ability to prepare for, recover from, and adapt to climate change and associated impacts.

Sequestration or Carbon Sequestration: Reducing the amount of carbon in the atmosphere through capturing carbon dioxide. This is done naturally through either geological or biological measures. For example, forests are a large source of carbon sequestration.

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March 1, 2024

Administrator Regan:

On behalf of the Commonwealth of Massachusetts, the Massachusetts Department of Transportation (MassDOT), in partnership with the Governor's Office of Climate Innovation and Resilience (Climate Office) and with contributions from agencies across Massachusetts state government, is proud to submit the Massachusetts Priority Climate Action Plan (PCAP) as the first deliverable required by the Climate Pollution Reduction Grant Planning Phase.

The goals of the Climate Pollution Reduction Grant program closely align with the climate mission of the Healey-Driscoll administration. Governor Healey created the Office of Climate Innovation and Resilience to spearhead a whole-of-government approach to climate action. Climate change affects all aspects of our lives. It requires us to transform on an accelerated basis how we travel, how we feed our communities, how we light and heat our homes, how we generate electric power and much more. Addressing the present and coming challenges requires urgent, coordinated action from every part of government. To that end, Climate Office works across government agencies to integrate climate into the strategies we are advancing to address major challenges in housing, transportation, public health, and energy.

This PCAP is the result of collaboration among state agencies, municipal governments, regional planning agencies and many organizations. We are grateful to the many voices that have shaped this Plan to prioritize the actions Massachusetts can take right now to reduce greenhouse gas emissions while delivering additional co-benefits to our communities.

The PCAP responds to the historic opportunity to accelerate climate action presented by the Biden Administration's Inflation Reduction Act. It is a commitment to our partnership to advance the Biden Administration's Justice40 initiative – a first ever goal for 40 percent of the benefits from certain federal investments to flow to disadvantaged communities that are underserved and overburdened by pollution. The PCAP will support our efforts to maximize federal investment in Massachusetts, and to maximize benefits in environmental justice communities that historically have been most impacted by pollution and who are also most vulnerable to future climate impacts.

Following the release of the PCAP, we will continue to engage with Massachusetts communities in the development of a Comprehensive Climate Action Plan (CCAP), which will cover all actions underway to mitigate greenhouse gas emissions in Massachusetts, identify the financial investment needed to meet our greenhouse gas reduction goals, and create a roadmap for delivering the benefits of climate action to environmental justice populations.

Thank you,

Melissa A. Hoffer Climate Chief Office of Climate Innovation and Resilience	Monica Tibbits-Nutt Secretary Massachusetts Department of Transportation

Introduction

Massachusetts is boldly rethinking how its residents will power the electric grid, heat buildings, and move around communities in a fossil fuel-free future. Decades of dependence on fossil fuels have created a climate pollution crisis that now affects every aspect of our lives from public health to state and local economies.[1] This Priority Climate Action Plan (PCAP) details some of the most effective and implementation-ready ways that state agencies and municipalities across Massachusetts can reduce climate pollution under the Climate Pollution Reduction Grant (CPRG) Phase II Implementation process.[2]

Massachusetts communities felt the impacts of climate change in new, widespread, and dire ways in 2023. In June, great expanses of forest in Quebec burned, sending clouds of harmful smoke over the eastern half of North America.[3] Later that summer, historically intense rainstorms caused flooding across inland New England, including western Massachusetts.[4] In August, a Merrimack Valley storm dropped over six inches of rain within six hours.[5] In September, Leominster experienced life-threatening flooding when ten inches of rain fell in the span of six hours.[6] For Massachusetts, the signals are clear that urgent change is necessary if we are to avoid the most severe impacts from greenhouse gas (GHG) emissions.

The impacts of recent climate events across Massachusetts build upon the disproportionate impacts that some Massachusetts communities have experienced over many years as a result

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[1] 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels, The Lancet, (November 2022). https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(22)01540-9.pdf; Karn Vohra, "Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem" Environmental Research, Volume 195, April 2021.https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487; Philip J. Landrigan, M.D., Howard Frumkin, M.D., Dr.P.H., and Brita E. Lundberg, M.D., "The False Promise of Natural Gas", The New England Journal of Medicine, January 9, 2020. https://www.nejm.org/doi/10.1056/NEJMp1913663

[2] U.S. Environmental Protection Agency, Climate Pollution Reduction Grants Program: Implementation Grants General Competition Notice of Funding Opportunity, January 2024. https://www.epa.gov/system/files/documents/2024-01/cprg-general-competition-correction.pdf

[3] Norimitsu Onishi, Fires Burning Where They Rarely Have Before, THE NEW YORK TIMES (June 8, 2023), https://www.nytimes.com/2023/06/09/world/canada/quebec-canada-wildfires-locations.html.

[4] Colin A. Young, Heavy rains damage crops, homes and flood the Connecticut River in western Mass., WBUR (July 12, 2023), https://www.wbur.org/news/2023/07/12/heavy-rains-damage-crops-homes-and-flood-the-connecticut-river-in-western-mass; John Bender & Irina Matchavariani, Many farms in Western Mass. may see extended damage as flood watch continues, WBUR (July 14, 2023), https://www.wbur.org/news/2023/07/14/western-massachusetts-farms-flood-crop

[5] Allison Kuznitz, North Andover tallies flood damage at $30 million, WBUR (Aug. 22, 2023), https://www.wbur.org/news/2023/08/22/north-andover-flood-damage-merrimack-valley-rain

[6] Michael Casey & Kathy McCormack, Heavy rain brings flash flooding in parts of Massachusetts and Rhode Island, ABC News (Sept. 12, 2023), https://abcnews.go.com/US/wireStory/heavy-rain-brings-flash-flooding-parts-massachusetts-rhode-103111095#:~:text=The%20Associated%20Press-,LEOMINSTER%2C%20Mass.,condition%20led%20to%20more%20evacuations; Paulina Villegas, 'Catastrophic' flooding causes damage and evacuations in Massachusetts, Washington Post (Sept. 12, 2023),https://www.washingtonpost.com/weather/2023/09/12/leominster-massachusetts-flash-flooding-fitchburg/.

of a fossil fuel energy system. Communities such as Chelsea and Springfield have long faced the impacts of our dependence on fossil fuels.[7] Called the state's "boiler room,"[8] Chelsea and its waterways serve much of New England's industrial needs, including storage for 100 percent of Logan International Airport's jet fuel, 70-80 percent of New England's heating fuel, road salt for over 300 municipalities, and trucked-in produce for much of New England. Chelsea's overall exposure to diesel exhaust exceeds the EPA's reference concentration by 20 percent, and the U.S. national average by five times. [9] The burden these industrial uses place on a community is evident in the cardiovascular and respiratory health of Chelsea's residents. Among all Massachusetts cities, Chelsea has the fifth highest rate of hospitalization from asthma-related diseases.[10] In 2016, age-adjusted hospital admissions for both asthma and chronic obstructive pulmonary disease in Chelsea were roughly twice the statewide average rate.[11] Similarly, Springfield was rated as one of the most challenging places to live with asthma in the United States based on assessment of the prevalence of asthmatic residents and rate of asthma hospitalizations.[12] The stories of Chelsea and Springfield are echoed in dozens of other Massachusetts communities with similar environmental burdens across all corners of the Commonwealth, from Adams to Fall River and Lawrence to Holyoke, and many others, in which the environmental burden of fossil fuel infrastructure – highways, power plants, fuel storage facilities, and vehicle depots – is proximate to the schools and homes of concentrations of residents who are lower-income than in other Massachusetts communities. Based on federal CEJST mapping criteria, Massachusetts includes 335 disadvantaged census tracts, with a total population of 1,300,810 people, a minority population of 663,411 people, and low income population of 893,215 people.

In response to these climate and equity imperatives, the Healey-Driscoll administration has adopted a whole-of-government approach to climate change, organizing state government to accelerate greenhouse gas emission reductions and to transition to a cleaner future centered on equity. The structural re-orientation of the Executive Branch to address climate has been bold and transformative. In January 2023, Governor Healey signed Executive Order 604 to

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[7] For a concise overview of Chelsea's relationship to climate and public health see: Clean Energy Solutions, Inc. "Chelsea Community Microgrid Feasibility Assessment." (2020) 8-11. https://greenjusticecoalition.org/wp-content/uploads/2021/04/RUN-GJC-Task-6-Chelsea.pdf

[8] Yvonne Abraham, *In Chelsea: the Deadly Consequences of Air Pollution*, THE BOSTON GLOBE, April 29, 2020. https://www.bostonglobe.com/2020/04/29/metro/chelsea-deadly-consequences-dirty-air/

[9] Faber, Daniel, and Eric Krieg. "Unequal Exposure to Ecological Hazards: Environmental Injustices in the Commonwealth of Massachusetts." Environmental Health Perspectives 110 no. 2 (1 April 2002): 277-288 hps://ehp.niehs.nih.gov/doi/10.1289/ehp.02110s2277

[10] Massachusetts Department of Public Health, *Asthma-Related Hospitalizations in Massachusetts*, 2022. https://www.mass.gov/doc/asthma-related-hospitalizations-in-massachusetts-pdf/download

[11] Center for Health Information and Analysis (CHIA) accessed from the MA DPH Public Health Information Tool (PHIT) https://www.mass.gov/orgs/population-health-information-tool

[12]Asthma and Allergy Foundation, Asthma Capitals. https://aafa.org/asthma-allergy-research/our-research/asthma-capitals/:

create the Office of Climate Innovation and Resilience as a catalyst for innovation and a central resource on climate policy across the Executive Branch. That function is largely focused on intersectional work: the interrelationships among building decarbonization, transportation electrification, grid decarbonization, and adaptation. The Climate Office elevates and connects that work across the Executive Branch agencies, building on the solid foundation developed by previous administrations, notably the 2007 reorganization of the then- Executive Office of Environmental Affairs to integrate the Departments of Energy Resources and Public Utilities, and by the Legislature, through its passage of innovative clean energy and climate laws, including the 2008 Global Warming Solutions and Green Communities Acts, and the 2022 Act Creating A Next-Generation Roadmap for Massachusetts Climate Policy and Act Driving Clean Energy and Offshore Wind. Climate Office is connected with each of the eleven Secretariats of the Executive Branch through a corps of Secretariat Climate Officers who coordinate climate policy within the workflow of each Secretariat.

The structural focus on climate across the Executive Branch has included equity and strategic use of federal funding. In February 2023, the Executive Office of Energy and Environmental Affairs appointed the first Undersecretary of Environmental Justice and Equity. In October, Governor Healey issued Executive Order 624 which established a unified Federal Funds and Infrastructure Office (FFIO), tasked with leading interagency coordination, promoting government-wide strategies for maximizing federal funds, and supporting the work of external partners to apply for federal funding opportunities, including through the new Massachusetts Federal Funds Partnership for municipalities and tribes. The Executive Order also established the Advisory Council on Federal Funds and Infrastructure, which includes designees from each executive office, and serves as the government-wide coordinating body for the Commonwealth's federal funds strategy. In October, the Climate Office issued a suite of thirty-nine recommendations pursuant to Executive Order 604 which detail specific measures to advance emissions reductions and resilience. And in February 2024, the Office of Environmental Justice & Equity within the Executive Office of Energy and Environmental Affairs, issued the first Environmental Justice Strategy for Massachusetts. The Environmental Justice Strategy addresses systemic environmental injustice by incorporating practices based on equity and inclusion into secretariats' everyday work and identifies concrete ways to increase public participation and ensure the voices of marginalized communities are at the table in setting policy and priorities. The Environmental Justice Strategy provides a roadmap for the Executive Branch to operationalize, imbed and implement environmental justice.

The steps taken in Massachusetts over the last year mark a continuation of decades of investment by Massachusetts taxpayers and ratepayers in programs that now serve as an example for other jurisdictions. Massachusetts is investing in climate leadership, guided by the priorities, principles, and opportunities of the Inflation Reduction Act. Those investments reflect two proven strategies that have undergirded Massachusetts climate leadership.

First, that innovation can yield demonstrated impacts. Massachusetts has a track-record of industrial innovation. In 2008, Governor Patrick signed legislation establishing a 10-year, $1 billion investment in Massachusetts life sciences. This landmark investment included a comprehensive plan to promote life sciences across all the sector from middle and high school classrooms, to workforce development, academic research and commercialization, to globally competitive businesses. Today, Massachusetts is again leveraging its unique capacity to drive innovation in its response to climate change, investing $1.3 billion in state funds in climatetech innovation to deliver economic benefits that advance climate goals.

The second strategy of Massachusetts climate leadership is to craft strong and innovative incentive programs in concert with regulatory programs to transform markets for clean energy. Massachusetts has undertaken efforts to pair aggressive stretch building codes with a $1.4 billion per year energy efficiency program; a power sector carbon reduction program with an allowance trading scheme that provides proceeds for reinvestment in energy efficiency; and a ban on the sale of internal combustion vehicles in 2035 with a nation-leading incentive program for the purchase of electric vehicles.

Over the last year, the strategies of innovation and incentive-based regulation have guided the following investments:

- In a historic $4 billion proposed Housing Bond Bill the Healey Administration has included $150 million to get fossil fuels out of public housing. The bill will prioritize the allocation of Low-Income Housing Tax Credits for new housing built in conformance with the stretch energy code and, for building retrofits will prioritize whole building electrification.[13]
- In Executive Order 626, Governor Healey addressed the intersectional issue of transportation reliability, and climate, establishing a Transportation Funding Task Force that will develop a long-term sustainable transportation funding plan. With participation from the Climate Chief, the Secretary of Energy and Environmental Affairs, and the Director of Federal Funds, among others, the Task Force is designed to address the long-term funding needs of a transportation system transitioning to electrification.[14]
- In a proposed Economic Development Bond Bill, the Healey Administration is seeking to commit $1.3 billion toward climate innovation driven by the Massachusetts Clean Energy Center, combining new bond authorization with tax credits for clean energy and climate tech companies to amplify Massachusetts' standing as a center of climate innovation.[15]

[13] See: https://www.mass.gov/lists/housing-bond-bill

[14] See: https://www.mass.gov/executive-orders/no-626-creating-the-governors-transportation-funding-task-force

[15] See: https://www.mass.gov/economic-development-bill

- The Healey administration has also proposed legislation that would unlock up to $750 million in state funding to aggressively pursue federal grant and program opportunities. The bill creates a Capital Investment and Debt Reduction Fund that would make available a combination of matching funds, loans, and technical assistance to various public entities to help maximize the state's competitiveness when seeking federal grants.[16]
- The creation of the Massachusetts Community Climate Bank with $50 million from the Climate Mitigation Trust Fund, specifically dedicated to develop innovative decarbonization programs in affordable housing units in which the Massachusetts housing finance agency, MassHousing, already acts as the primary lender.[17]

Massachusetts is also laser focused on the sequestration side of the equation, developing new ways to conserve, manage and protect forests, wetlands and other natural and working lands. Massachusetts state agencies have collaborated in new ways and adapted existing forestry programs to incorporate a climate mandate. Over the last year, an interagency group led by the Climate Office and the Executive Office of Energy and Environmental Affairs, convened expert foresters, forest ecologists, and climate scientists as a 12-member group of distinguished scientific experts who were convened as the Climate Forestry Committee (CFC). The group met eight times over 2023 in an initiative to develop the first ever state recommendations on how to ensure we are managing state forests to meet our CECP goals and creating the incentives that will protect private forests.[18] The final report and resulting initiative, Forests As Climate Solutions, will expand existing state programs, invest in forest conservation, enhance a network of forest reserves, and develop forest management guidelines based on the latest climate science. These guidelines will apply to state lands, and the Healey-Driscoll Administration is developing strong incentives for private landowners to adopt them to maximize the climate benefits of their forests.

At the same time, Massachusetts is using existing programmatic channels to better address climate workforce development and education. The Executive Office of Education expanded upon the exiting Innovation Pathways program. Innovation Pathways are designed to give high school students coursework and experience in a specific high-demand industry, such as information technology, engineering, healthcare, life sciences and advanced manufacturing. In September 2023, the Secretariat of Education awarded grants to six schools for them to expand this program to include a Clean Energy Pathway, enabling the purchase of practical equipment,

[16] See: https://malegislature.gov/Bills/193/S2482

[17] See: https://www.mass.gov/news/governor-healey-announces-creation-of-massachusetts-community-climate-bank-nations-first-green-bank-dedicated-to-affordable-housing

[18] Climate Forestry Committee Final Report. https://www.mass.gov/doc/forest-as-climate-solutions-climate-forestry-committee-report-final/download

such as heat pumps, for students to develop real-world skills as the workforce of the clean energy future.[19]

Massachusetts is also working regionally to partner with Northeast states to make the investments needed to transform the region's electric power grid. The Executive Office of Energy and Environmental Affairs led the creation of an historic collaboration with neighboring states of Rhode Island and Connecticut for a joint procurement of offshore wind capacity to supply New England.[20] Similarly, Energy and Environmental Affairs is convening neighboring states to lay the groundwork for regional transmission to enhance the availability of clean electricity across the Northeast.

Massachusetts is also confronting the most salient structural issues that impede implementation of the defined decarbonization measures from the Clean Energy Climate Plan, in particular regulatory issues related to historic disinvestment by utilities in existing gas and electric distribution systems, that now is delaying interconnection of renewable and grid modernization.

The natural gas system offers a complex set of obstacles to building sector decarbonization, including how to tactically orchestrate a transition from gas to electric heat, how to ensure low-income ratepayers do not bear an energy burden for remaining on a gas system as other users transition to electric, and how to ensure the safe operation of gas pipeline infrastructure amidst declining volume. In 2020 the Department of Public Utilities opened a proceeding to address regulatory issues associated with the gas distribution system given the statutory mandate to decarbonize the economy. After three years of stakeholder meetings, expert testimony and technical sessions, the Department issued its Order in December 2023 mandating a number of new planning processes to coordinate between electric utilities and gas distribution companies. The order also mandates greater transparency in how gas distribution companies calculate gas system investments and requires an assessment of non-pipeline alternatives.[21]

The current electric distribution system also presents obstacles to implementation of the broad electrification measures necessary to decarbonize the buildings, transportation, and power sectors. The issues of the electric system are rooted in the need to both increase the capacity of segments of the electric system for increased electric load and to make the electric distribution system more capable to respond in real time to changes in supply and demand of electricity. This need translates into new technologies, systems and processes for electric utilities, customers and distributed generation developers. Massachusetts is addressing one aspect of

[19] See: https://www.mass.gov/news/the-healey-driscoll-administration-awards-planning-grants-to-31-high-schools-to-expand-innovation-career-pathways-6-high-schools-preparing-brand-new-clean-energy-pilot

[20] See: https://www.mass.gov/news/massachusetts-rhode-island-and-connecticut-sign-first-time-agreement-for-multi-state-offshore-wind-procurement

[21] MASSACHUSETTS DEPARTMENT OF PUBLIC UTILITIES, DPU 20-80B Order on Regulatory Principles and Framework, https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/18297602

the constraints in the electric system through a clean energy facility siting commission, led by the Executive Office of Energy and Environmental Affairs. That commission will develop legislative and regulatory proposals to address local issues around the siting of renewable energy. In addition, the commission will address the process of interconnection which currently creates eight-year delays in deployment of renewable energy. Separately, the Grid Modernization Council has created a process for electric utilities to submit Electric System Modernization Plans with stakeholder engagement. Those plans, submitted in January 2024, detail the specific investments that utilizes need to make to support the electrification scenario that is key to economy wide decarbonization, including engagement of an Environmental Justice Working Group.

Finally, in October 2023, the Climate Office issued a major report with thirty-nine recommendations each of which address specific goals to achieve decarbonization and resilience, with a central focus on analyzing the level of investment required to meet our legislatively mandated net zero limit and the Commonwealth's most pressing resilience needs, and developing clear funding and financing pathways. Recommendations vary in scope, including structural reform to how Massachusetts incorporates climate into capital planning as well as discrete projects, such as rapid acceleration of electric vehicle charging infrastructure across state government. Those recommendations are tracked in a central project database, have inter-agency teams assigned to them, and are being implemented across the Administration.[22]

Massachusetts has approached its PCAP by leveraging its proven leadership, its two decades of experience, its intersectional coordination and its sense of urgency in addressing the climate crisis.

PCAP and CPRG Purpose

This PCAP, developed as part of a U.S. Environmental Protection Agency (EPA) Climate Pollution Reduction Grant Phase I Planning Grant, is the first deliverable required by the CPRG process. It represents a highly focused, near-term list of implementation ready measures to support state agencies, municipalities, regional planning agencies, and federally recognized Tribal Nations to compete for CPRG Phase II Implementation grants.

The content of this PCAP supplements – but does not replace—the pathways and actions described in the Massachusetts Clean Energy and Climate Plan for 2025/2030. Instead, this plan is designed as a tactical resource for applicants seeking CPRG Phase II Implementation grants. It is not designed to serve as a comprehensive list of policy and program recommendations for Massachusetts to reduce its emissions to net zero by 2050.

[22] Office of Climate Innovation and Resilience, Recommendations of the Climate Chief Pursuant to Section 3(b) of Executive Order 604, October 2023. https://www.mass.gov/files/documents/2023/10/24/CLIMATE%20REPORT.pdf

This PCAP also provides a foundation for the next phase of work under the CPRG Planning Phase: development of the Comprehensive Climate Action Plan (CCAP). While the PCAP deliberately focuses on near-term implementation-ready measures to support CPRG Implementation Grant proposals, the CCAP will serve a more strategic purpose and provide additional detail for both near-term and long-term GHG emission reduction goals. According to the U.S. EPA CPRG Program, Massachusetts will develop and submit the Comprehensive Climate Action Plan by July 1, 2025.

Based on the work undertaken as a part of development of the Clean Energy Climate Plans, consultation with stakeholder groups, and assessment of state and federal funding opportunities, the Priority Climate Action Plan includes the following Priority Measures:

Table 1: List of Measures

Sector	GHG Reduction Measures
Transportation	**T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles**
	T2. Adopt Zero Emission Light-Duty Vehicles
	T3. Increase Alternatives to Personal Vehicle Use
Buildings	**B1. Increase Building Efficiency**
	B2. Decarbonize Building Heating Systems
Power	**P1. Develop New Renewable Energy Facilities**
	P2. Implement Building-Scale Renewables
	P3. Maximize Utilization of Clean Energy
Natural and Working Lands	**N1. Implement Nature-Based Solutions**
Waste	**W1. Reduce Organic Waste Through Composting**

Building on Massachusetts Climate Leadership

This Priority Climate Action Plan builds on over fifteen years of climate leadership in Massachusetts. Building on the Commonwealth's longstanding leadership on climate issues—including the Commonwealth's historic victory in Mass. V. EPA, which confirmed the authority of the U.S. Environmental Protection Agency (EPA) under the Clean Air Act to regulate greenhouse gas emissions; its role in founding the Regional Greenhouse Gas Initiative (RGGI), the first regulated power sector cap and trade program; and its recent establishment of the Massachusetts Community Climate Bank, the first green bank in the Nation to focus on affordable housing decarbonization— Massachusetts is poised to lead the Nation and the world in creating opportunity and resilience amid extreme climate crises.

With the passage of the Global Warming Solutions Act (GWSA) in 2008, Massachusetts became one of the first states to create a comprehensive regulatory program to reduce greenhouse gas emissions. The GWSA requires EEA to issue, every five years, a Clean Energy and Climate Plan[23] and to set interim limits on greenhouse gas emissions for 2030 and 2040.[24]

In 2016, the Massachusetts Supreme Judicial Court issued its decision in Kain v. DEP holding that the GWSA requires the Department of Environmental Protection (DEP), through the promulgation of regulations, to set actual limits for sources or categories of sources that emit greenhouse gases.[25] The Court further held that DEP is required to promulgate regulations that address multiple sources or categories of sources of greenhouse gas emissions, impose a limit on such emissions that may be released, limit the aggregate greenhouse gas emissions that are released from each group of regulated sources or categories of sources, set greenhouse gas

[23] An Act Establishing the Global Warming Solutions Act, Chapter 298 of the Acts of 2008, Section 6, amending Chapter 21N, Climate Protection and Green Economy Act, Section 5. (https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298)

[24] An Act Establishing the Global Warming Solutions Act, Chapter 298 of the Acts of 2008, Section 6, amending Chapter 21N, Climate Protection and Green Economy Act, Section 3(b). (https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298)

[25] Kain v. Department of Environmental Protection, 474 Mass. 278 (2016).

emissions limits for each year, and set limits that decline on an annual basis.[26] In 2018, the Supreme Judicial Court issued its decision in New England Power Generators Association, upholding the Department's authority to establish annually declining aggregate carbon dioxide emissions limits on electricity generating facilities located in the Commonwealth.[27]

In 2019, EEA began development of the 2050 Decarbonization Roadmap which, in turn, resulted in the Interim Clean Energy and Climate Plan for 2030. In 2021, An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy (2021 Climate Law) amended the GWSA and established the requirement for Massachusetts to adopt a statewide limit for 2050 that achieves at least Net Zero emissions by 2050, codified environmental justice criteria into law, and required sector-based statewide greenhouse gas emissions sub limits.[28] To meet the 2050 requirement, the 2021 Climate Law required additional interim statewide greenhouse gas emissions limits such that interim limits are now required for 2025, 2030, 2035, 2040, and 2045; each interim limit is required to be accompanied by a comprehensive, clear, and specific roadmap plan to realize the limit.[29]

On June 30, 2022, EEA determined the appropriate statewide emissions limits for 2025 and 2030 and released an accompanying CECP to achieve those limits.[30] On December 21, 2022, Massachusetts adopted a statewide greenhouse gas emissions limit, Net Zero, and sector-specific sub limits for 2050.[31] "Net Zero" means a level of statewide greenhouse gas emissions that is equal in quantity to the amount of carbon dioxide or its equivalent that is removed from the atmosphere and stored annually by, or attributable to, the Commonwealth, and a reduction of greenhouse gas emissions by at least 85 percent relative to the 1990 baseline.[32,33] On that same date, EEA released the CECP 2050 for Massachusetts which sets forth the method for Massachusetts to achieve Net Zero in 2050 in an equitable and just manner. Specifically, the CECP 2050 "incorporates strategies to reduce negative environmental impacts and increase investments in environmental justice communities."[34]

Based on this legal foundation, the Commonwealth of Massachusetts has developed the analytic foundation to address climate change over the last fifteen years. First, pursuant to the

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[26] Id. at 291-92

[27] New England Power Generators Association, Inc. v. Department of Environmental Protection, 480 Mass. 398 (2018).

[28] An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, Chapter 8 of the Acts of 2021, Section 8. 88 Id.

[29] Id.

[30] MASSACHUSETTS EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, Massachusetts Clean Energy and Climate Plan for 2025 and 2030, Letter from the Secretary, p. iv https://www.mass.gov/doc/clean-energy-and-climate-plan-for-2025-and-2030/download (June 2022) [hereinafter CECP 2025/2030]

[31] MASSACHUSETTS EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, CECP 2050, supra note 37, at p. i.

[32] "Net Zero" is used throughout the CECP as a specific term to refer to the established statewide GHG emissions mandate for 2050. This report uses "net zero" in its more general sense to refer to a level of GHG emissions that is equal in quantity to the amount of GHG that is removed from the atmosphere.

[33] MASSACHUSETTS EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, CECP 2050, supra note 37, at p. i.

[34] Id.

2008 Global Warming Solutions Act (GWSA), the Department of Environmental Protection created a baseline inventory of greenhouse gas emissions. Second, over the last few years Massachusetts has issued three reports that build on the *Inventory* to chart a pathway for climate action: the *Decarbonization Roadmap* published in December 2020, the *Clean Energy Climate Plan for 2025-2030* published in June 2022, and *the Clean Energy Climate Plan for 2050* published in December 2022. Taken together, this has established an economy wide GHG inventory, GHG Emissions Projections, and plans to achieve mandated GHG emissions reductions.

The PCAP and the CECPs

This PCAP builds upon the data, analysis, substantive actions and engagement processes of the Massachusetts' Clean Energy and Climate Plans for 2025/2030 and 2050.

Grounded in the 2021 *Act Creating a Next Generation Roadmap for Massachusetts Climate Policy,* the CECPs act as a "roadmap" for how Massachusetts will achieve its greenhouse gas emissions reduction goals and charts a pathway for economy wide GHG reductions to comply with the statutory requirement of 50 percent GHG reduction in 2030; 75 percent in 2040; 85 percent and Net Zero in 2050. Based on a model of Massachusetts emissions, the CECPs project emissions trajectories for a set of scenarios each of which could meet Massachusetts reduction goals. Taken as a whole, each scenario projects clear milestones for adoption of major kinds of clean energy infrastructure, such as electric vehicles, air source heat pumps, and solar generation. The CECPs also make policy recommendations for how the Commonwealth can achieve those milestones. The 2025/2030 and 2050 CECPs resulted in over 97 actions for investments, programs, and policies to achieve the mandated decarbonization targets. The following figure shows the economy-wide emissions by sector.[35]

The PCAP leveraged the actions of the CECPs as an initial suite of implementation-ready measures for how Massachusetts can achieve its climate goals. Although additional concepts emerged from municipalities and stakeholders throughout the engagement process, the pathways of the CECPs as well as the emissions reduction potential as defined in the GHG Inventory, helped to define the selection of priority measures. In particular, the PCAP development process focused on the three sectors responsible for the greatest share of Massachusetts emissions: transportation, buildings, and power generation.

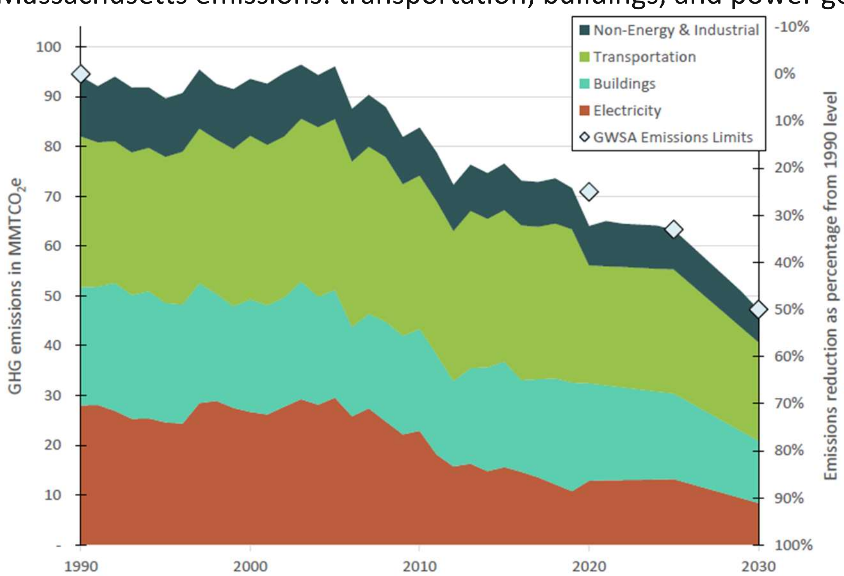

Figure 1: Economy-Wide GHG Emissions by Sector

[35] Massachusetts Clean Energy and Climate Plan for 2025 and 2050, pg. xii

The CECPs present 1990 historical greenhouse gas emissions data and establish sub limits by sector for 2025, 2030, and 2050, which work together to achieve the requirement of reaching Net Zero in 2050 when taken in combination with the amount that is removed from the atmosphere and attributable to the Commonwealth. These sub limits are presented in the table below. These values provide context for the overall GHG emissions reductions that can be expected from individual sectors during the periods 2025-2030 and 2025-2050.

Table 2. CECP Sub limits in $MMTCO_2e$[36]

Sector	1990	2025	2030	Difference 2025-2030	2050	Difference 2025-2050
Transportation	29.6	24.9	19.8	-5.1	4.1	-20.8
Buildings (residential and commercial)	23.8	17.2	12.5	-4.7	1.7	-15.5
Industrial Energy	5.6	2.9	2.5	-0.4	0.3	-2.6
Electric Power	28.2	13.2	8.4	-4.8	2.0	-11.2
Natural Gas Distribution and Service	1.9	0.4	0.4	0.0	0.5	0.1
Industrial Processes	0.7	3.6	2.5	-1.1	0.8	-2.8
Agriculture and Waste	3.4	1.0	0.9	-0.1	1.1	0.1

The CECP actions were the product of an extensive public engagement process in 2021 and 2022. Based on the long-standing consultative process with the Global Warming Solutions Act Implementation Advisory Committee, the staff of the Executive Office of Energy and Environmental Affairs held multiple public meetings and received rounds of stakeholder comment on initial versions of the CECP.[37] Many of those comments helped to inform the development of the PCAP. In addition, the Climate Justice Workgroup issued two sets of recommendations on the CECP which also served as sources of comment for the PCAP.[38] Accordingly, the record of public engagement underlying the CECP is consistent with the process expectations of the CPRG Program.

[36] Values for 1990 and 2050 are taken from the 2050 CECP within the sections for the individual sectors. Values for 2025 and 2030 are taken from the 2025/2030 CECP within the sections for the individual sectors.
[37] See https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2025-and-2030#public-engagement-

[38] See https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2025-and-2030#public-engagement-).

Development of the PCAP

The CPRG process benefitted from three sources of input:

- CECP actions and associated state agency program design and expertise;
- the climate action plans of various regions and municipalities;
- the input from community organizations and municipal staff

The process began with a focus on the Massachusetts Inventory and the main actions from the CECP to focus reductions on the largest emitting sectors of transportation, buildings, and power generation. Focusing on those measures, the CPRG staff also reviewed existing climate action plans and received input from community members.

Based on the suite of measures gathered from the CECP and consultation with stakeholders and municipalities, CPRG staff refined the CECP measures and other recommendations to prioritize those topics that met US EPA criteria for near-term actionable projects with emissions reductions focused on the 2025-2030 timeframe. This process included several elements of selection consistent with the guidance of the CPRG Planning Phase and Implementation Phase program.

First, the PCAP focuses on measures – policies, projects and programs – that can achieve meaningful greenhouse gas emissions reductions and benefit low income and disadvantaged communities. This evaluation is based on the Massachusetts GHG Inventory and the emissions attributed to elements within each sector, such as medium- and heavy-duty transportation.

Second, the PCAP focuses on measures which can play a strategic role in the state's broad suite of decarbonization programs, either by filling a gap or by integrating existing programs in new ways. This evaluation is based on a review of the existing state programs and funding for emissions reduction measures.

Third, the PCAP focuses on measures that might have broad appeal across municipalities, stakeholder organizations and residents as a way to rapidly transform and replicate emissions reductions. The PCAP attempts to be responsive to areas of particular interest among municipalities, such as electrification of municipal buildings and removal or organics from municipal waste streams.

The PCAP process involved soliciting public input from community organizations and municipalities on a draft list of priority categories and engaging state agencies, municipalities, and community organizations and Regional Planning Agencies coordinating the MSA applications on specific project types.

Other PCAPs covering parts of Massachusetts are being developed by:

- Metropolitan Area Planning Council
- Central Massachusetts Regional Planning Council
- Southeast Regional Planning and Economic Coordination Council
- Wampanoag Tribe of Gay Head Aquinnah
- Mashpee Wampanoag Tribe

Funding Assessment

In October 2023, Governor Healey established the Federal Funds & Infrastructure Office as the lead agency within the Healey-Driscoll Administration tasked with implementing a whole of government approach to ensuring the Commonwealth of Massachusetts can leverage the historic opportunities available for federal funding. The FFIO supports state agencies and municipalities in pursuing federal funding opportunities available under the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA).

Since 2022, Massachusetts state and municipal government agencies have aggressively applied for a range of federal funding opportunities available under the BIL and IRA across the transportation, buildings, power, and waste sectors. The availability of these federal funding opportunities influenced the development of this PCAP, as well as development of several individual priority measures, in three important ways.

First, consideration of federal funding highlighted those measures for which CPRG Implementation would meet an unmet need. For example, the Massachusetts federally-funded programs for electric vehicle charging infrastructure, such as the National Electric Vehicle Infrastructure Plan and Clean Fuel Infrastructure, focus on light-duty vehicles. The preponderance of funding oriented to light-duty electric vehicles underscored the incremental benefit from focusing CPRG implementation-ready measures on medium- and heavy-duty vehicles. Similarly, the HERS-HEARS rebate programs will focus on end-use customers to accelerate adoption of home electrification. The Massachusetts Solar for All Program and the pipeline of projects supplied to the bidders for the National Clean Investment Fund also focus on end-use adoption incentives. There remains a gap in programs that address the deployment supply chain and vendor network for air source and ground source heat pumps. This unmet need highlights the opportunity for CPRG funds to address distribution market dynamics of the heat pump industry. The Massachusetts CPRG priority measures emphasize areas that can provide federal funding to areas incremental to that already achieved by Massachusetts.

Second, this PCAP strategically reflects the way in which federal funding can integrate and multiply state programs. Massachusetts has significant state-funded programs to support many of the actions identified in the CECPs. This CECP focused on measures for which CPRG Implementation Grant funding could provide a strategic point of leverage to existing state funding. For example, Massachusetts has a $23 million “Accelerating Clean Transportation” program funded to provide school bus fleet conversion advisory services. The program offers free fleet advisory consulting services to municipalities for them to chart a path to electrify their fleet. This state program has allowed Massachusetts municipalities to compete for US EPA Clean School Bus Rebate and Clean School Bus Grant programs. Similarly, Massachusetts ratepayers fund a nation leading energy efficiency program, MassSave. MassSave provides incentives to end-users for home improvements to increase energy efficiency and to adopt electric air source and ground source heat pumps. Those incentives, totaling about $1.3 billion annually, are focused on end-use customers across all customer classes. Given the robust programmatic focus of MassSave, Massachusetts created the Massachusetts Community Climate Bank at MassHousing to attract Greenhouse Gas Reduction Fund (National Clean Investment Fund) dollars into products that will work alongside MassSave.

Based on the significant down-payment made by Massachusetts taxpayers and ratepayers on the actions identified in the Clean Energy Climate Plans, this PCAP highlights opportunities for federal funding to fill gaps and multiply the impact of state funding.

Third, engagement with the federal funding process has elevated the integration of policy development, fiscal planning and environmental justice. In its Environmental Justice Strategy, the EEA Office of Environmental Justice and Equity specifies that it will work in close coordination with the newly created Office of Federal Funds and Infrastructure and the Advisory Council on Federal Funds and Infrastructure to ensure all grant opportunities across all agencies have meaningful input from the environmental justice communities and are distributed in an equitable manner in order to have the most impactful outcome while meeting theJustice40 Initiative threshold targets.

Illustrative Massachusetts Applications for Federal Funding by Sector

Transportation

- Clean School Bus Grant: Boston, Fall River, Worcester, New Bedford, Fitchburg, Springfield
- Clean School Bus Rebate: Fall River, Bourne/Upper Cape, West Springfield, Lawrence, New Bedford
- National Electric Vehicle Infrastructure Plan
- Clean Fueling Initiative 2023

Buildings

- Energy Efficiency Contractor Training
- Energy Auditor Training
- State Based Home Energy Efficiency Contractor Training Grants
- Home Efficiency Rebates
- Home Electrification and Appliance Rebates
- Greenhouse Gas Reduction Fund – Solar for All
- Greenhouse Gas Reduction Fund – National Clean Investment Fund (pipeline of projects)

Power

- Port Infrastructure Development 2023
- Grid Resilience and Innovation Program 2023
- Grid Resilience and Innovation Program 2024

Low Income and Disadvantaged Communities Benefits Analysis

This PCAP includes a qualitative analysis of benefits for low income and disadvantaged communities (LIDACs) to inform the design of implementation programs and policies.

Consistent with Executive Order 14008, the federal government has identified an overarching goal that 40 percent of the overall benefits of certain federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution. The CPRG program implements that commitment, requiring each PCAP to conduct a qualitative analysis of how each of the priority measures may create benefits or disbenefits within identified LIDAC communities.

Massachusetts has a robust definition of environmental justice. The Act Creating a Next Generation Roadmap for MA Climate Policy, defines an "environmental justice population" as, "a neighborhood that meets one or more of the following criteria: (i) the annual median household income is not more than 65 percent of the statewide annual median household income; (ii) minorities comprise 40 percent or more of the population; (iii) 25 percent or more of households lack English language proficiency; or (iv) minorities comprise 25 percent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 percent of the statewide annual median household income..." This definition currently includes over 2.4 million Massachusetts residents and is an important gauge for how state programs operate and how energy, environmental and health policy interact. Both the Executive Office of Energy and Environmental Affairs and the Department of Public Health maintain mapping tools that help to identify environmental justice populations and detail layers of impacts that affect them. The most recent Environmental Justice Strategy issued in February 2024 advances environmental justice policy into a specific set of practices.

In order to draw comparative conclusions across multiple states, the US EPA instructed states to use federal tools that rely on federal criteria to define "Low Income and Disadvantaged Communities" (LIDAC). The use of the criteria and definition of LIDAC in this PCAP does not reflect a policy preference for the federal standard. For this PCAP, the determination was made to use census tracts included as disadvantaged in the Climate and Economic Justice Screening Tool (CEJST). The CEJST tool uses datasets that are indicators of burdens in eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. The tool ranks most of the burdens using percentiles by Census tract. Percentiles show how much burden each tract experiences compared to other tracts. To qualify as a disadvantaged community in CEJST, one of the burden indicators must be above the 90^{th} percentile. Accordingly, the CEJST tool helps to identify the most disadvantaged communities in Massachusetts. In contrast to other mapping tools which include a greater number of residents within environmental justice designated populations based on a broader set of criteria, the CEJST tool focuses on the populations most clearly defined as LIDAC by federal standards. The criteria that CJEST relies upon to define LIDAC communities appears in Table 3.

CEJST and EJScreen

The Climate and Economic Justice Screening Tool (CEJST) was created by the Council on Environmental Quality (CEQ) to highlight disadvantaged census tracts across the United States. Communities are considered disadvantaged if the census tract meets the threshold for at least one of the dataset's categories of burden or if they are on land within boundaries of Federally Recognized Tribes. Census tracts that are surrounded by disadvantaged communities and are at or above the 50 percentile for low income are also considered disadvantaged. According to this dataset there are 335 disadvantaged census tracts across Massachusetts, with a total population of 1,300,810 people, a minority population of 663,411 people, and low income population of 893,215 people.

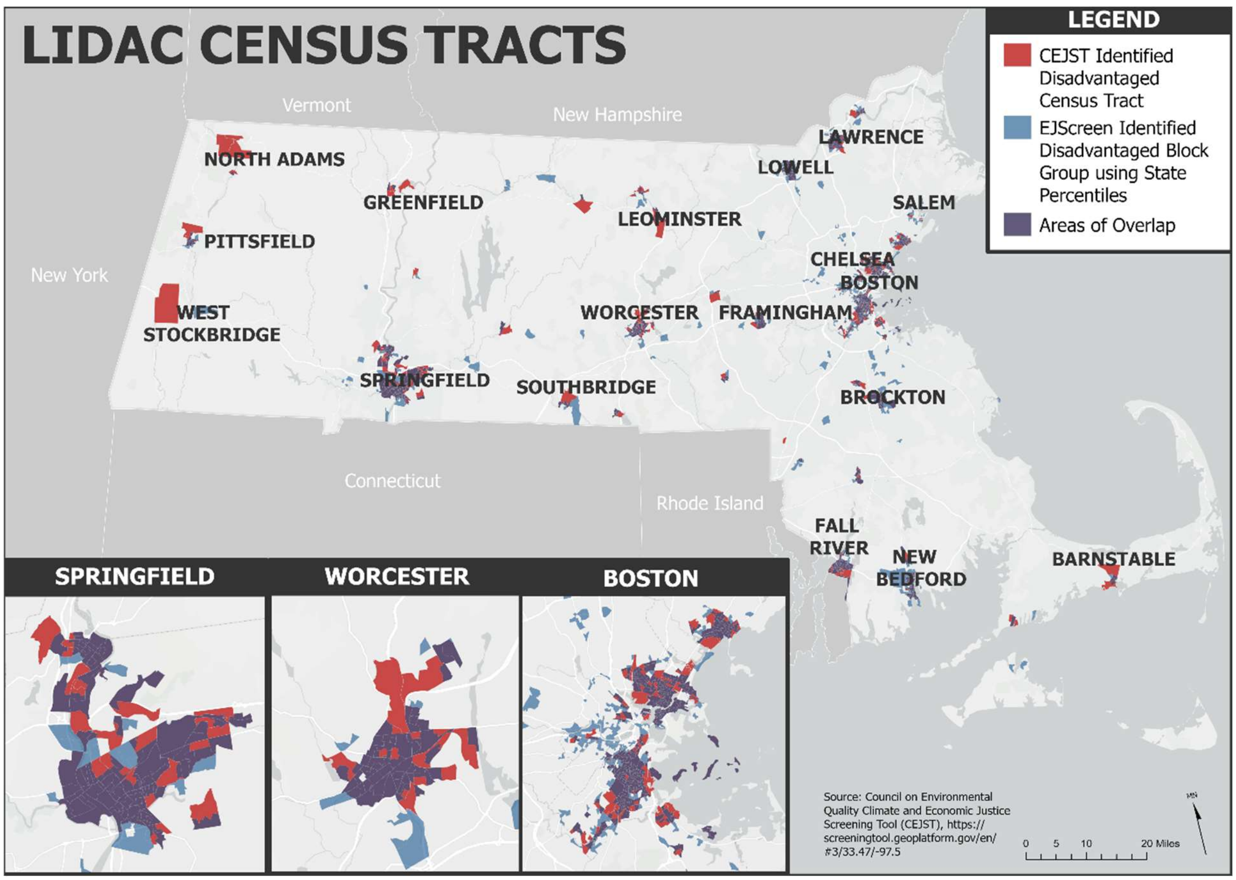

Figure 2: CEJST LIDAC Census Tracts compared to EJScreen MA LIDAC Block Groups

The PCAP also consulted EJScreen Supplemental Index US Percentiles, a data layer created by US EPA. Each supplemental index combines socioeconomic indicators with a single environmental indicator. This includes the US percentiles compiled for EJScreen, the EPA's environmental justice mapping and screening tool that provides a consistent dataset and approach for combining environmental and demographic socioeconomic indicators. EJScreen Supplemental Index MA Percentiles compares only the state percentiles for Massachusetts. EJScreen relies on block groups instead of census tracts, a smaller area within census tracts. This provides a larger disadvantaged population than the CEJST dataset. Using EJScreen US the total LIDAC population in MA is 1,235,317 and using EJScreen MA the total LIDAC population in MA is 1,583,849.

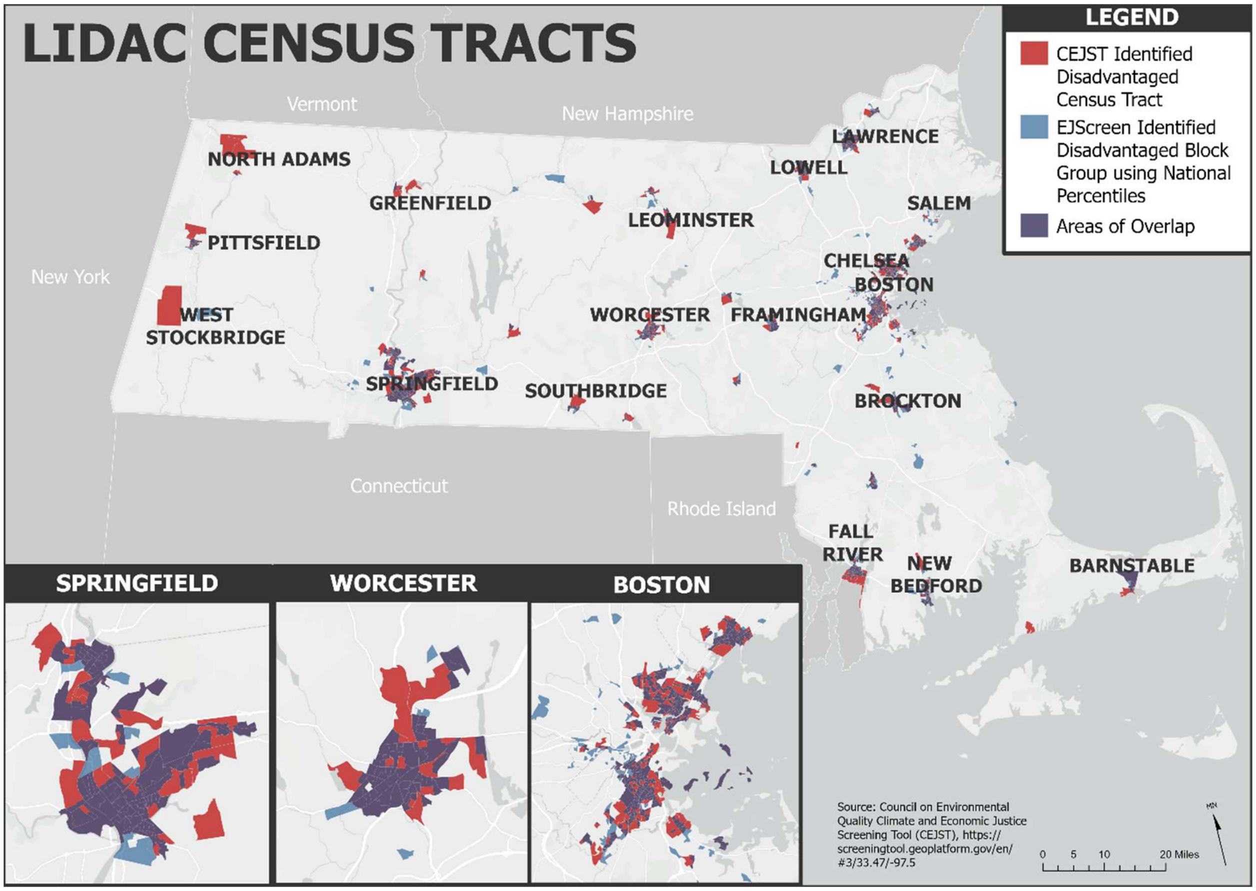

Figure 3: CEJST LIDAC Census Tracts compared to EJSCREEN US LIDAC Block Groups

Table 3: CEJST Categories and Indicators

CEJST Category	Indicators
Climate Change	Expected agriculture rate, expected building loss rate, expected population loss rate, projected flood risk, projected wildfire risk AND low income
Energy	Energy cost, PM2.5 in the air AND low income
Health	Asthma, diabetes, heart disease, low life expectancy AND low income
Housing	Housing cost, lack of green space, lack of indoor plumbing, lead paint AND low income
Legacy Pollution	Abandoned mine land, formerly used defense site, proximity to hazardous waste facilities, proximity to risk management plan facilities, proximity to superfund sites AND low income
Transportation	Diesel particulate matter exposure, transportation barriers, traffic proximity and volume AND low income
Water and Wastewater	Underground storage tanks and releases, wastewater discharge AND low income
Workforce Development	Linguistic isolation, low median income, poverty, unemployment AND high school education

Within Massachusetts, CEJST identifies 335 census tracts (of 1,471 total statewide census tracts) as disadvantaged under these standards. These tracts represent 20.3 percent of Massachusetts' population. The full table of census tracts is in Appendix A.

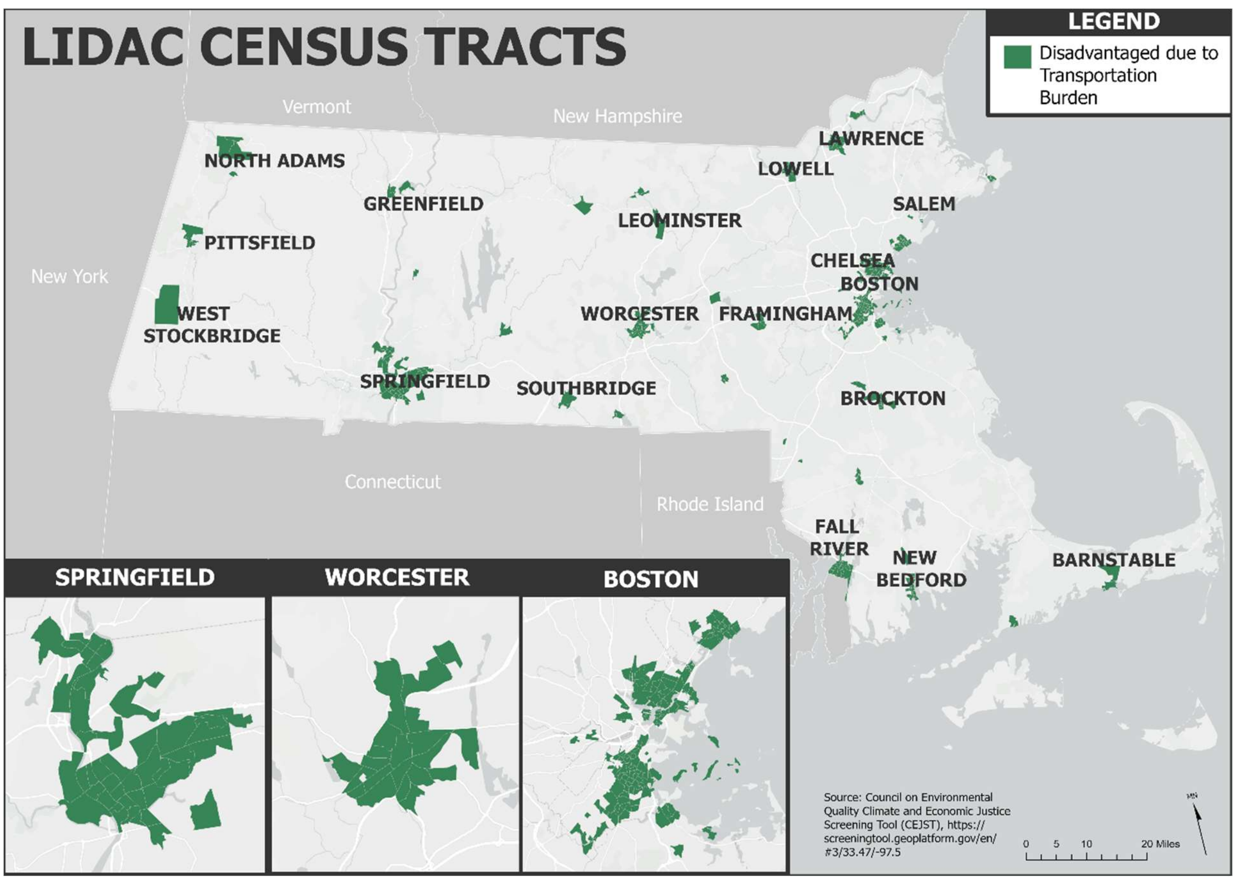

Figure 4: LIDAC Census Tracts

LIDAC Factor Details

Census Tracts Burdened by Energy Cost

CEJST identifies 72 census tracts as meeting more than one energy burden threshold and above the 65th percentile for low income households. Of the 72 census tracts, all tracts were above the 90th percentile for energy cost burden and zero tracts met the burden threshold for PM2.5 in the air. Energy cost was calculated by average annual energy cost divided by household income. There is a concentration of census tracts in Springfield averaging high energy cost.

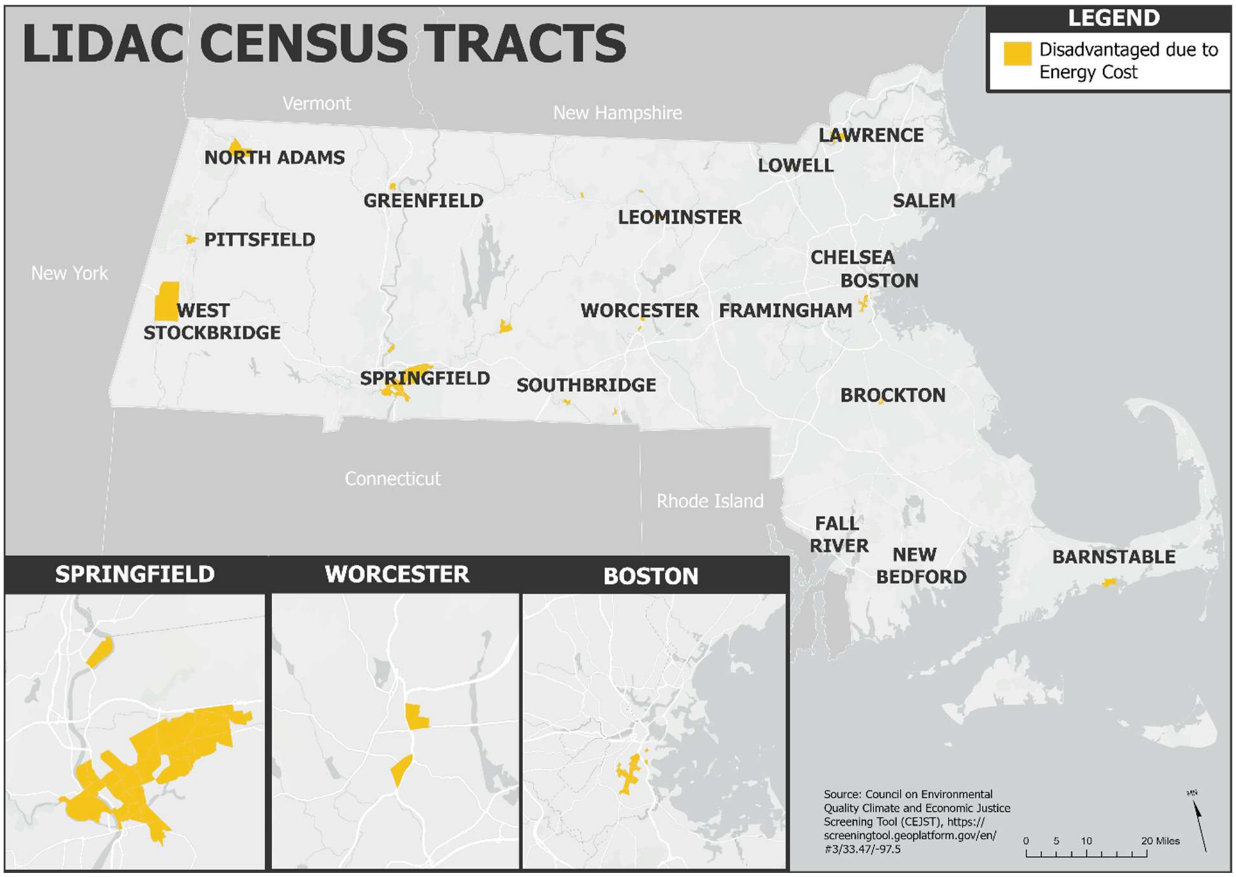

Figure 5: LIDAC Census Tracts disadvantaged due to Energy Cost

Census Tracts Burdened by Peaker Plants

For the purpose of this analysis, peaker plant information was sourced from the EPA and defined as using 10 percent capacity or less. These are fossil fuel combustion power plants that are turned on to supply power when demand is at a maximum. 109 CEJST identified disadvantaged tracts are within 3 miles of a peaker plant. 13 of the 21 peaker plants in Massachusetts are near LIDAC census tracts, with an increased number of peaker plants on the eastern half of the state.

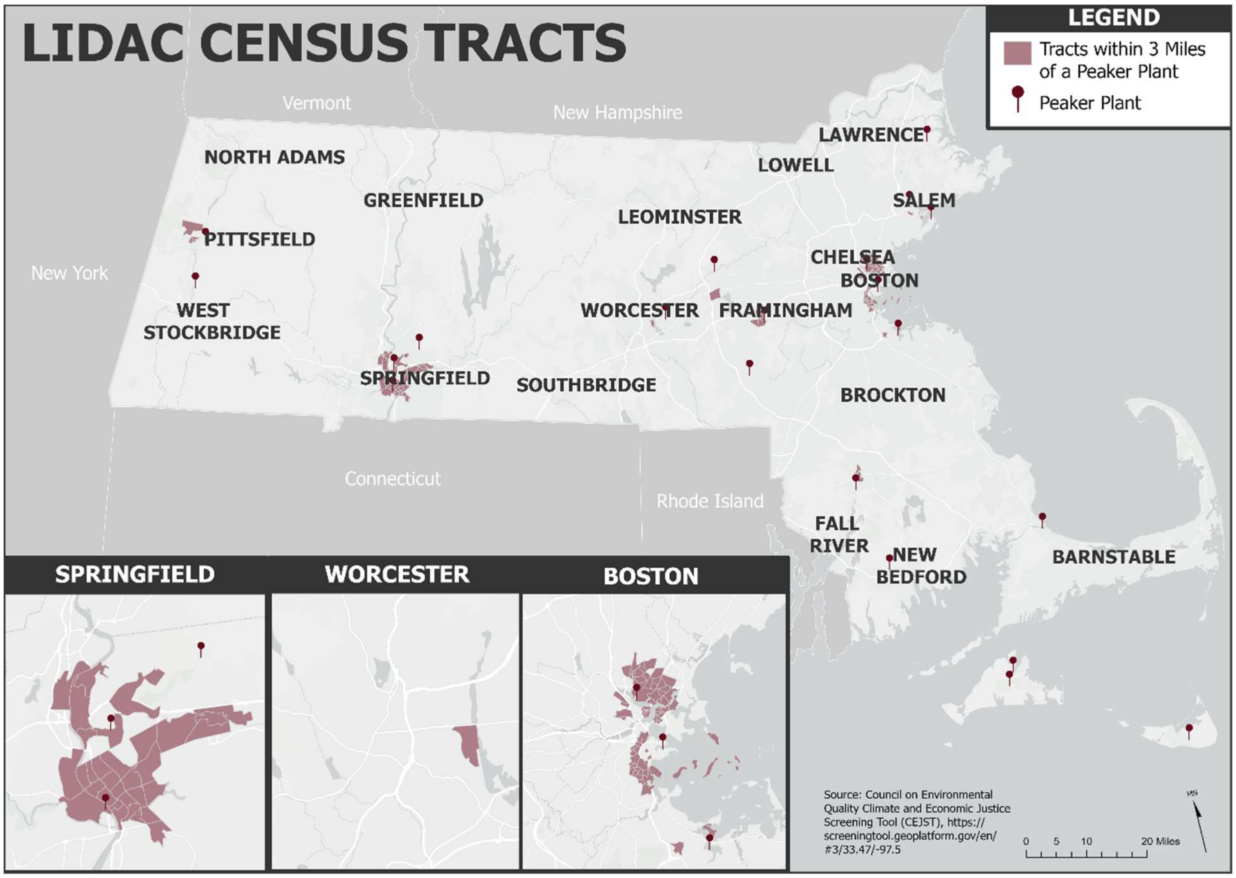

Figure 6: LIDAC Census Tracts within 3 Miles of a Peaker Plant

Census Tracts Burdened by Transportation Factors

175 of the 335 identified LIDAC census tracts meet one or more of three transportation burden thresholds: diesel particulate matter exposure, transportation barriers, or traffic proximity and volume. Majority of tracts exceed the 90th percentile threshold for traffic proximity and volume, calculated by the count of vehicles at major roads within 500 meters.

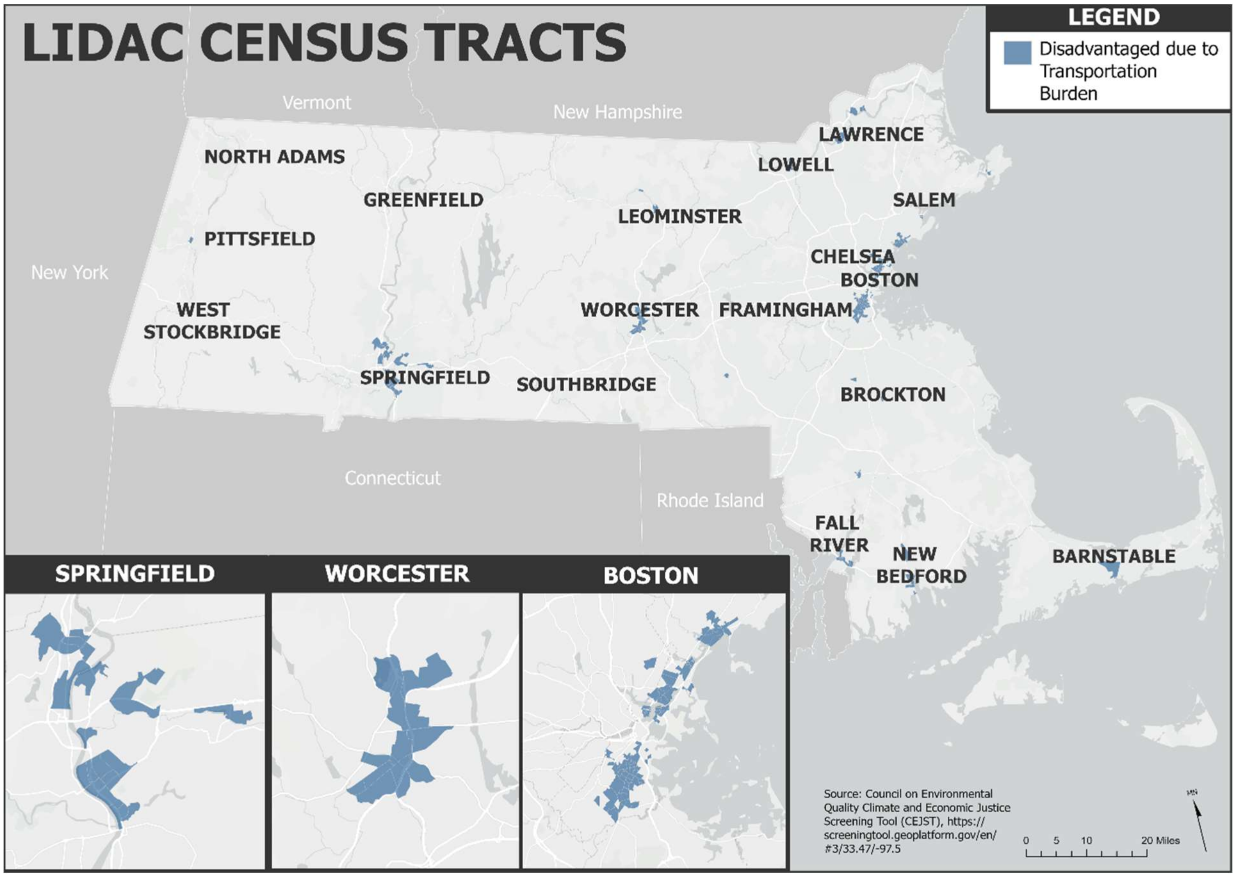

Figure 7: LIDAC Census Tracts disadvantaged due to a Transportation Burden

Census Tracts Burdened by Diesel Particulate Matter Exposure and Transportation Barriers

The LIDAC census tracts that are burdened by diesel particulate matter exposure and transport barriers are all located within Boston and its surrounding area. Census tract 9803 is the only tract above the 90th percentile for transportation barriers.

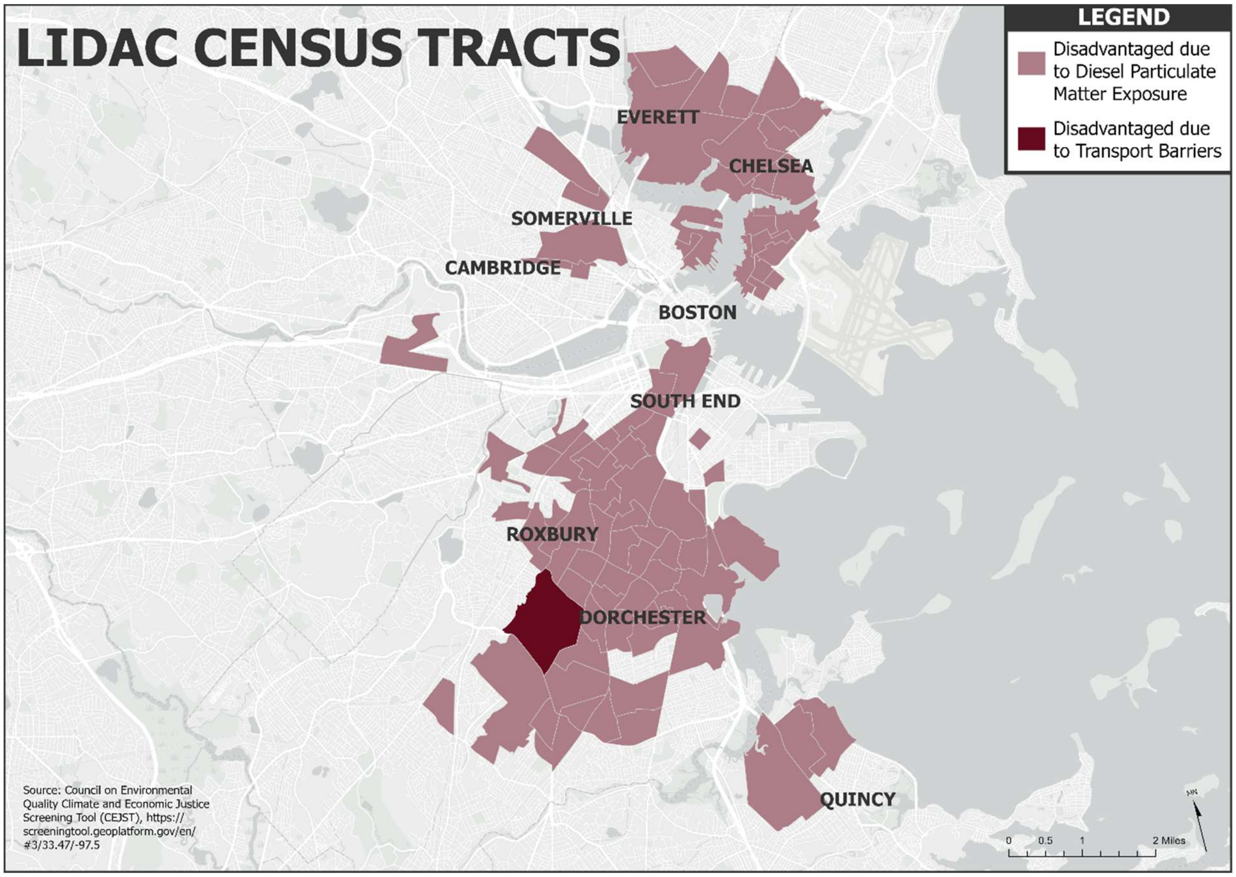

Figure 8: LIDAC Census Tracts disadvantaged due to Diesel Particulate Matter Exposure and Transport Barriers

Census Tracts Burdened by Health Factors

Within Massachusetts, 154 census tracts meet a health burden threshold. 93 percent of the 154 census tracts are above the 90th percentile for share of people who have been told they have asthma. For these communities, the benefits from improved air quality are potentially most impactful.

According to the 2011, *Massachusetts Climate Change Adaptation Report*, combustion of fossil fuels negatively impacts public health in several ways. Combustion produces, nitrous oxides, ozone and fine particulate matter all of which contribute to air pollution and associated respiratory and cardiovascular disease. Principal public health concerns are allergy symptoms related to increased allergen production and increased respiratory and cardiovascular disease. Particularly vulnerable populations include the elderly; the very young; low income groups; immigrants; the unhoused; un- or under-insured people; residents with increased exposure to ambient asthmagens; residents of older or substandard housing; people who are geographically isolated from health care services; people with certain pre-existing conditions, especially asthma or lung dysfunction or compromised immune systems; and outdoor laborers such as farm and construction workers.

These health impacts result in significant economic impacts for individuals and for the Commonwealth at large. The economic impacts stem from lost workdays and additional health care costs that accrue to either individuals or to the health care system as a whole to support care for vulnerable citizens who are most at risk from environmental impacts.

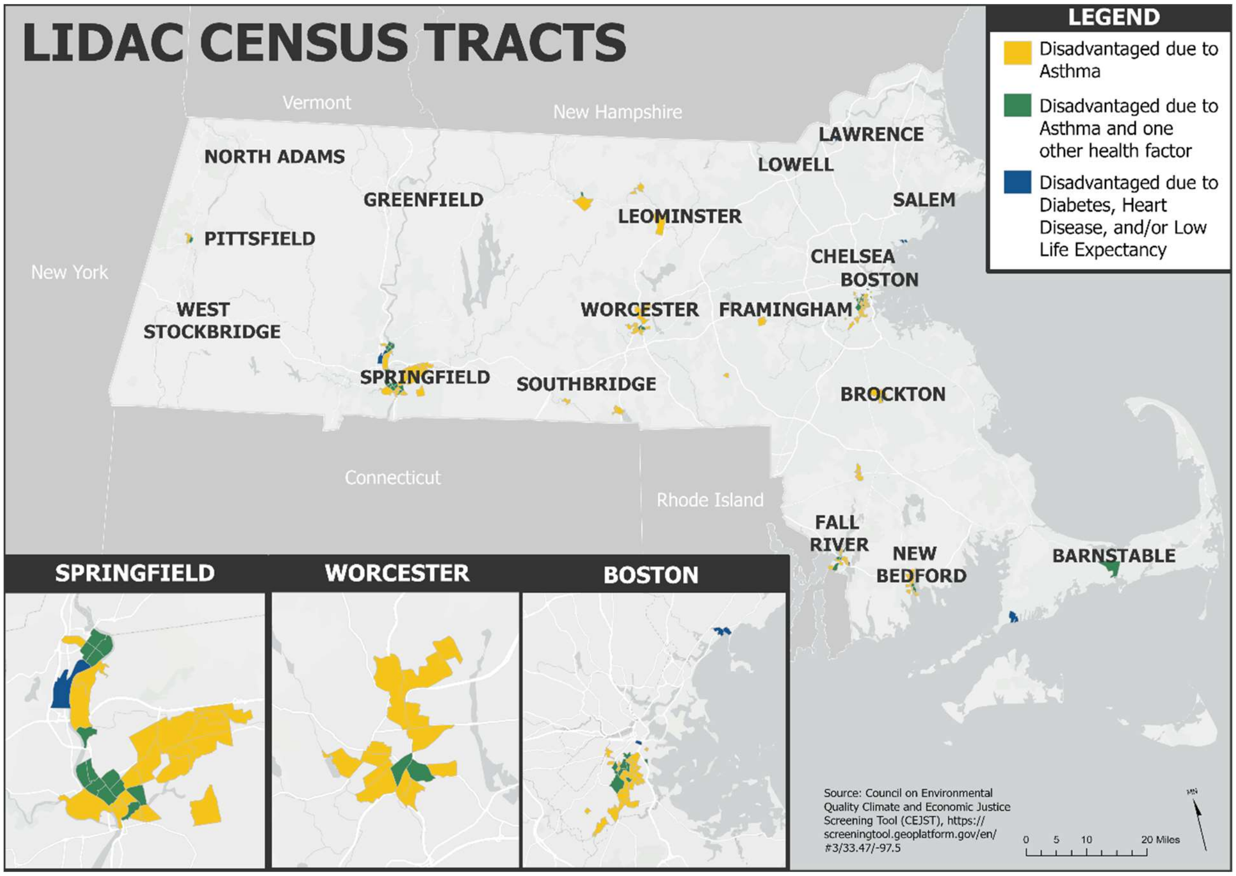

Figure 9: LIDAC Census Tracts disadvantaged due to Public Health Factors

LIDAC Application to Measures

The PCAP discusses specific benefits of each PCAP as they pertain to LIDACs as a part of each measure discussion. Many of the proposed measures are not limited to a specific geography, as the share of building types (commercial, residential, municipal, schools, etc.) and the use of vehicles and energy types are spread broadly across the Commonwealth. As such, impacts and benefits are likely to be felt across all communities. However, the Commonwealth may choose to prioritize funding for some measures towards LIDACs to ensure benefits such as job and skill development are accumulated in areas of need. Some measures will have geographic-specific impacts, which are noted in the discussion of each of those measures.

Table 4 below describes the qualitative types of benefits that pertain to each measure.

Table 4: LIDAC Benefits for each GHG Reduction Measure

GHG Reduction Measures	LIDAC CEJST Impact Categories
Transportation	
T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles	**Health, Transportation burdened community members** Population: 774,595 Percent of state population: 11%
T2. Adopt Zero Emission Light-Duty Vehicles	**Health, Transportation burdened community members** Population: 774,595 Percent of state population: 11%
T3. Increase Alternatives to Personal Vehicle Use	**Transportation burdened community members** Population: 514,121 Percent of state population: 7%
Buildings	
B1. Increase Building Efficiency	**Energy, Health, Workforce Development burdened community members** Population: 1,230,227 Percent of state population: 18%
B2. Decarbonize Building Heating Systems	**Energy burdened community members** Population: 254,899 Percent of state population:4%
Power	
P1. Develop New Renewable Energy Facilities	**Energy, Health, Legacy Pollution, Workforce Development burdened community members** Population: 1,262,902 Percent of state population: 18%
P2. Implement Building-Scale Renewables	**Energy, Health, Workforce Development burdened community members** Population: 1,230,227 Percent of state population: 18%
P3. Maximize Utilization of Clean Energy	**Energy, Workforce Development burdened community members** Population: 1,142,247 Percent of state population: 16%
Natural and Working Lands	
N1. Implement Nature-Based Solutions	**Climate Change, Health burdened community members** Population: 638,790 Percent of state population: 9%
Waste	
W1. Reduce Organic Waste Through Composting	**Water and Wastewater, Workforce Development burdened community members** Population: 1,105,180 Percent of state population: 16%

In addition to a range of potential benefits, the measures identified in this PCAP may potentially result in disbenefits to the communities in which they are located, or which may be affected by implementation of each measure. It is essential that any authority – state, municipal or regional – seek to minimize the disbenefits through careful coordination with community organizations, residents, and local government. Some potential disbenefits are specific to the type of measure while others may apply to any measure based on how it interfaces with local communities.

Two types of disbenefits pertain to each of these measures regardless of the sectoral focus. First, all the measures have the potential, if implemented without meaningful community engagement, to widen a gap in communication between community residents and organizations with government policies and programs. An example of such an impacts could be clean energy citing without community awareness or input, or electric vehicle charging infrastructure installation without community coordination on locations. Meaningful and continued community engagement in all stages of each measure is essential for successful implementation. A second type of disbenefit that could potentially arise from the measures if they are not implemented with in partnership with communities would be a widening of socio-economic differences among communities. Without deliberate consultation and careful guardrails, the structural differences among communities that have exacerbated over decades may replicate through implementation of these measures. For example, statewide or municipal incentive programs for clean power generation, building decarbonization or clean transportation may result in those residents or communities who are in a position to benefit to do so, leaving others without benefit. Careful design and consultation in all phases of measure implementation may mitigate this potential disbenefit.

Intergovernmental coordination

The PCAP development process has benefitted from close coordination among the state agencies, regional planning entities, and municipalities. The state solicited input from local and regional officials from across Massachusetts in several forums. CPRG Planning staff convened biweekly meetings with the Regional Planning Agencies responsible for developing PCAPs for each of the three Metropolitan Statistical Areas: The Metropolitan Area Planning Council, the Central Massachusetts Regional Planning Council, and the Southeastern Regional Planning and Economic Development District. In addition, the CPRG Planning staff attended meetings convened by each of the Regional Planning Agencies (RPA) with municipal partners. The CPRG Planning staff also convened two general meetings with RPA staff to solicit feedback on PCAP measures as well as a meeting focused on the 26 Gateway Cities in Massachusetts with high environmental justice and immigrant populations. In addition, CPRG Planning staff presented the draft priority measures to a meeting of the Massachusetts Municipal Partnership which included over 250 municipal officials. Based on that outreach, the CPRG Planning staff held one-on-one meetings with several municipal and regional entities including the Cape Cod Commission, the Franklin County Regional Planning Agency, the Berkshire County Regional Planning Agency, Pioneer Valley Regional Planning Commission, the City of Boston, the City of Chelsea, and the City of Lawrence. In addition, the Massachusetts CPRG Team attended the environmental justice council and municipal council meetings of the MSA PCAP processes. These convenings provided additional opportunities for the state CPRG Team to listen to municipal and community leaders from the MSA regions which comprise over 70 percent of Massachusetts population.

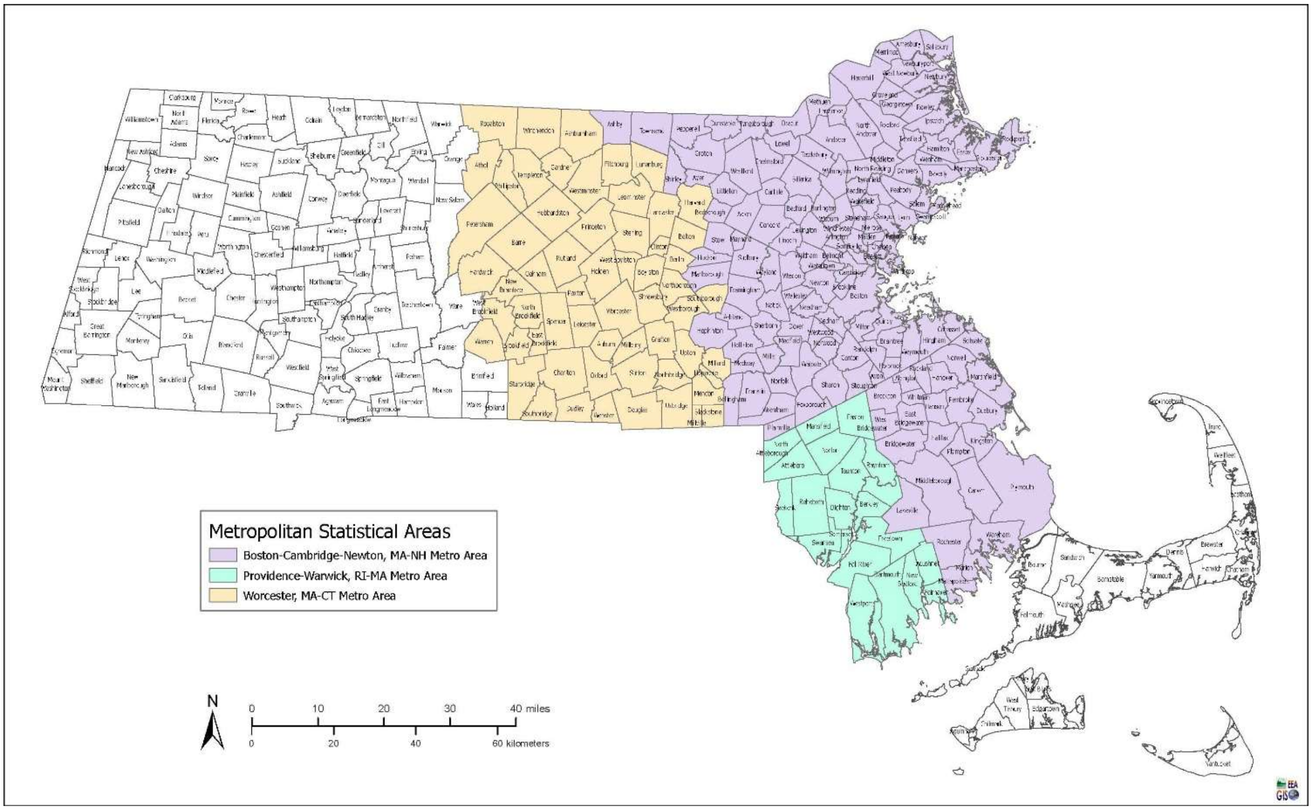

Figure 10: Massachusetts Metropolitan Statistical Areas

Community Stakeholder Engagement

Throughout the PCAP development process the CPRG Planning Team engaged community organizations to solicit concepts and feedback on priority areas for inclusion in the PCAP.[39] The Massachusetts CPRG community engagement plan deliberately sought to integrate the CPRG process with existing stakeholder processes whenever possible to avoid creation of additional burden on organizations already engaged in extensive consultative processes.

The CPRG PCAP development process leveraged existing forums of the [Global Warming Solutions Act Implementation Advisory Council] (GWSA IAC). The GWSA IAC includes over 18 independent experts in climate mitigation. The GWSA IAC played a consultative role in the development of the CECP in 2022. The GWSA IAC met with the CPRG Project Staff in June and October 2023 to discuss potential project measures and to understand how the PCAP could best build upon the areas identified in the CECP. In addition, the GWSA sector work groups related to transportation, buildings, and power each met with the CPRG team to provide specific input on the measures within each sector.

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[39] https://www.mass.gov/info-details/implementation-advisory-committee

The CPRG PCAP development process also leveraged the existing Environmental Justice Council. to receive high-level feedback on the environmental justice priorities of leading organizations across the Commonwealth.

The Climate Office solicited written input to the PCAP in three phases: first, a detailed survey to evaluate and prioritize measures in the fall of 2023; secondly, a public comment period for input on the final list of priority measures in January 2024; lastly, a public comment period in February 2024 to review the first draft of the PCAP. Across these three input periods, the Climate Office received 180 comments.

Environmental Justice

The CPRG team worked closely with the Environmental Justice Office of the Secretariat of Energy and Environmental Affairs to convene a monthly Justice40 and Equitable Investment Working Group. With over 75 organizations invited and consistent participation from about 35organizations, the Justice40 Group represents an important cross-section of environmental justice organizations from across the Commonwealth representing community members from many federally defined LIDAC communities. The Justice40 Group met in monthly virtual meetings beginning in September 2023. By March 1, 2024 the Justice40 Group will have met six times to address topics related to the CPRG PCAP as well as other federal funding opportunities, such as Solar for All. In addition to these groups, the CPRG team held multiple small-group conversations with environmental justice leaders to address particular topics and to hear their perspective on priority areas for the PCAP and decarbonization priorities overall. These small meetings highlighted important topics, such as the increased 41energy burden that may arise from electrification of affordable housing or existing mapping tools to track the environmental justice burden on communities across the Commonwealth. The CPRG staff used interactive tools including jamboards and surveys to solicit feedback on existing topics and new ideas.

In February 2024, the CPRG Team held two community meetings to further solicit input on the straw-proposal Priority Climate Action Plan. At these two meetings, which over 100 people attended, community members and advocates shared their perspectives on the suite of priority measures included in the PCAP as well as the three measures that state agencies had identified as potential candidates for implementation grant proposals. These discussions, interpreted into four languages (Spanish, Portuguese, Mandarin and French Creole), focused on how each proposal could build meaningful and ongoing community engagement.

This work bore out the commitment of the Office of Environmental Justice and Equity to support meaningful engagement with environmental justice communities for grant applications and serve as a liaison with community- based organizations across the Commonwealth. The Office of Environmental Justice and Equity worked throughout the process to ensure all relationships with environmental justice communities are based on mutuality, respect, and solidarity.

Climate and Labor

The CPRG team also established a new monthly engagement process with labor organizations through a Climate-Labor Working Group. These monthly meetings engaged one dozen leaders and representatives drawn from of the Massachusetts and Boston Buildings Trades Council, the AFL-CIO, the International Brotherhood of Electrical Workers, and the Policy Group on Trades Women's Issues in monthly meetings. Those meetings addressed topics of how decarbonization projects could include worker protections and ensure development of high-quality jobs at the same time as promoting the diversification of the Massachusetts workforce to include women and people of color.

In addition to meeting with the established groups listed above, the CPRG team met with municipalities and individuals across the Commonwealth to inform specific priority climate action measures and potential CPRG implementation grants. Altogether, CPRG staff held over 45 meetings with organizations. A full list of CPRG stakeholder engagement meetings can be found in Appendix M.

Greenhouse Gas Inventory

Massachusetts, in alignment with its commitment to combat climate change, conducts a comprehensive GHG inventory annually. The state's GHG inventory serves as a crucial tool in assessing and understanding the sources and trends of these emissions, providing policymakers and the public with valuable insights. By regularly monitoring and reporting the state's carbon footprint, Massachusetts strives to develop effective strategies and policies that contribute to the larger goal of mitigating climate change impacts and fostering a sustainable future.

Scope and Methodology

The Massachusetts Department of Environmental Protection (MassDEP) has developed a statewide inventory of the major sources of GHG emissions resulting from economic activities in the state. The Massachusetts GHG emissions inventory includes anthropogenic emission estimates for primary GHGs for the full geographic coverage of the state across sectors. Emissions are reported in CO_2 equivalent units. The Massachusetts inventory includes tracking of emitted and sequestered gases from the following sectors: residential fuel combustion, commercial fuel combustion, industrial fuel combustion, electric power, transportation, natural gas systems, industrial processes, agriculture, and waste. For the purposes of the PCAP, these sectors were re-categorized as listed above for better alignment with the approved CPRG Quality Assurance Project Plan (QAPP) and for reduction measure calculations. Data sources for the sector-based inventory are provided in Appendix B.

Table 5: Statewide Inventory by Sector and Gas

Sectors	Greenhouse Gases (across all sectors)
• **Transportation** • **Electric power** • **Industry** • **Commercial and residential buildings** • **Waste and materials management** • **Wastewater** • **Agriculture** • **Natural and working lands**	• Carbon dioxide (CO_2) • Methane (CH_4) • Nitrous oxide (N_2O) • Fluorinated gases (F-gases) including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3)

GHG Emissions by Sector

To conduct long-term analyses and track priority reduction measures, 2019 GHG emissions have been used for the PCAP. Total reported emissions for 2019 are 71.67 $MMTCO_2e$; total reported emissions do not account for sinks from natural working lands.[40] 2019 data is more complete and reliable for assessing the trajectory of emissions, considering the abnormal conditions related to the COVID-19 pandemic of 2020-2021.

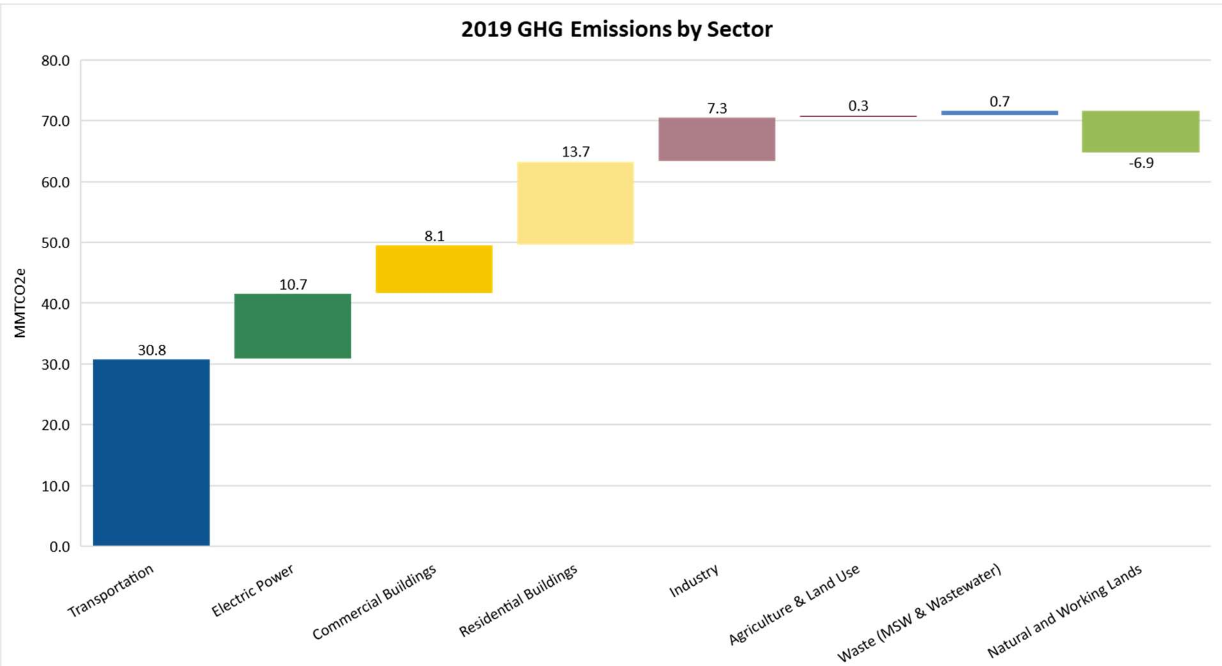


Figure 11: 2019 GHG Emissions by Sector

The inventory data provides insights into the major contributors to Massachusetts's overall carbon footprint. Sectors are categorized to demonstrate their respective contributions to the total GHG emissions, offering a comprehensive overview of the state's environmental impact.

[40] Biogenic combustion emissions are excluded from Figure 11, as MA's GHG limits (other than the 2050 net zero limit) are based on gross emissions.

The three largest contributors to the state's inventory include the following:

Figure 12: Massachusetts Largest Emitting GHG Sectors in 2019

- **Transportation** sources are the largest contributor representing 43 percent of the state's GHG emissions. Emissions from this sector primarily come from the combustion of gasoline, diesel, and aviation fuel. In 2019, 62 percent of sector emissions were from gasoline and 26 percent were from diesel from on-road vehicles.
- **Buildings** on-site fuel combustion across the residential and commercial represent 30 percent of the state's GHG emissions. On-site combustion in industrial buildings is not included in this sector, but rather in the Industrial Sector. Consistent with national and international convention, the GHG emissions from buildings cover the emissions from the combustion of fossil fuels on-site for space and water heating. GHG emissions associated with electricity usage are reported in the electric power sector.
- **Electric Power** represents 15 percent of the state's GHG emissions. These GHG emissions include in-state generation of electricity and imported electricity from other states. The use of electricity to heat and cool buildings and vehicle charging in Massachusetts is included within this sector.

Industry, Agriculture, and Waste make-up the remaining 12 percent of emissions. Industry emissions includes energy consumption in industrial buildings, emissions from manufacturing processes, natural gas distribution, and various other industrial activities. Agriculture includes emissions from activities such as livestock management, crop production, and land management. Waste and Wastewater sector encompasses emissions from waste management activities, including municipal solid waste combustion that does not generate electricity, landfill methane generation, and wastewater disposal and treatment.

Natural Working Lands is not included in the gross emissions, as it represents a natural carbon sink. This sector in Massachusetts' GHG inventory encompasses emissions and removals of GHGs associated with land use, land management, and forestry practices, encompassing natural carbon cycling in land under management and not only fluxes directly associated with active management.

Priority GHG Reduction Measures

Massachusetts GHG inventory data demonstrates transportation, buildings, and power sectors as the largest emissions contributors across the state. Priority measures are focused on making meaningful reductions to these key sectors while also increasing the potential for carbon sequestration from natural and working lands through activities that are achievable, ambitious, and provide community benefits.

Overview of Measures

The measures listed are not exhaustive to reach goals and targets in alignment with the Clean Energy and Climate Plan but are specifically identified in alignment for potential CPRG implementation grants. The following priority measures meet the following EPA PCAP requirements:

- Programs, policies, or projects are implementation ready in the near-term timeline of five-years from grant award.
- Significant GHG emissions reductions will be achieved from implementation as compared to the 2019 GHG inventory baseline.
- Low income and disadvantaged communities will benefit from implementation.

Quantified GHG emissions reductions included for each measure are calculated referencing the Massachusetts 2019 baseline GHG Inventory. Refined emissions calculations that include forecasting will be completed in the future CCAP.

Transportation is a top priority sector for the state so that progress can be made to significantly increase the adoption of reduced emission transportation opportunities. Whereas, the Building sector already has traction on newer technology adoption, improved energy codes, and many existing funding programs that are expected to continue.

Table 6: Priority Reduction Measures

Priority Reduction Measure	Implementation Concepts (non-exhaustive)	2019 GHG Baseline	CPRG Emission Reduction Potential by 2030
Transportation			
T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles	Medium-duty transit vans, delivery vans/trucks, school buses	30.81 $MMTCO_2e$ (Scope 1)	0.14 $MMTCO_2e$
	Heavy-duty vehicles, including large trucks and transit buses		
T2. Adopt Zero Emission Light-Duty Vehicles	Low/Zero emission passenger vehicles		2.00 $MMTCO_2e$
T3. Increase Alternatives to Personal Vehicle Use	Increase short-distance transportation alternatives		0.37 $MMTCO_2e$
	Expand and electrify rail service		
Buildings			
B1. Increase Building Efficiency	Renovate/Retrofit existing commercial buildings	21.76 $MMTCO_2e$ (Scope 1)	Scope 1: 1.07 $MMTCO_2e$ Scope 2: 0.27 $MMTCO_2e$
	Renovate/Retrofit existing housing stock		
	Renovate/Retrofit existing schools		
B2. Decarbonize Building Heating Systems	Increase heat pump adoption		Scope 1: 4.35 $MMTCO_2e$
	Expand geothermal adoption		
Power			
P1. Develop New Renewable Energy Facilities	Accelerate onshore and offshore wind development	10.72 $MMTCO_2e$ (Scope 2)	5.05 $MMTCO_2e$
	Increase solar PV development		
P2. Implement Building-Scale Renewables	Install on-site renewable energy		0.62 $MMTCO_2e$
P3. Maximize Utilization of Clean Energy	Develop municipal microgrids		0.28 $MMTCO_2e$
	Electric grid investments		
Natural and Working Lands			
N1. Implement Nature-Based Solutions	Conserve existing forests and increase restorative planting	-6.9 $MMTCO_2e$ (Scope 1 and 2)	0.36 $MMTCO_2e$
Waste			
W1. Reduce Organic Waste through Composting	Divert food waste from landfills	0.3 $MMTCO_2e$ (Scope 1)	0.04 $MMTCO_2e$

Transportation

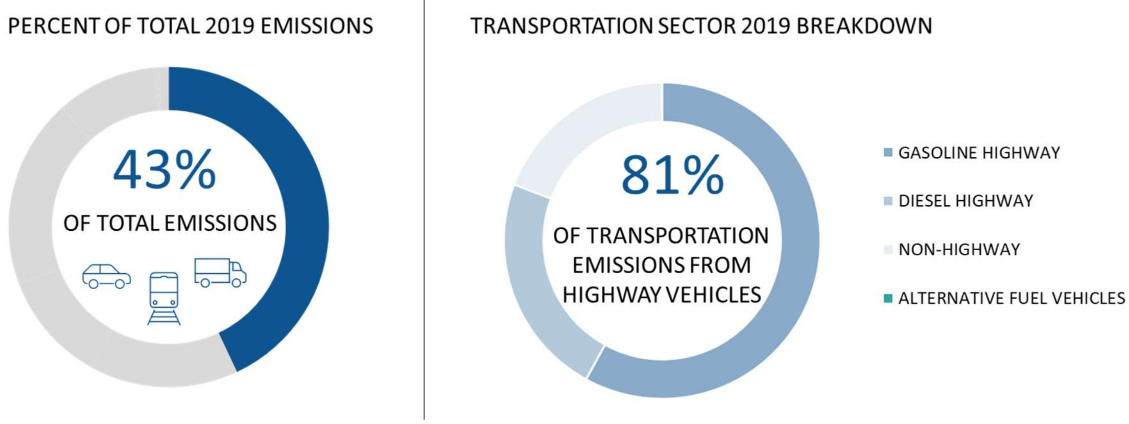


Figure 13: Transportation Sector 2019 Emissions

Historically, transportation across the United States has been reliant on individual automobiles fueled by internal combustion engines. However, advancements in technology and policy, coupled with strategic investments throughout Massachusetts, can pave the way for a transformed transportation landscape. Transportation priority actions have been created with the goal of creating a future where residents can navigate with reduced reliance on driving and better technology that results in decreased emissions.

The following table shows the 1990 historical GHG emissions and sector sub limits from the 2025/2030 and 2050 CECPs for the Transportation sector. These values provide context for the overall GHG emissions reductions that can be expected from this sector during the periods 2025-2030 and 2025-2050.

Sector	1990	2025	2030	Difference 2025-2030	2050	Difference 2025-2050
Transportation	29.6	24.9	19.8	-5.1	4.1	-20.8

In Massachusetts, transportation emissions primarily contribute to the release of carbon dioxide (CO_2), nitrogen oxides (NOx), volatile organic compounds (VOCs), particulate matter (PM), and other pollutants. The transportation sector includes emissions from highway vehicles, aviation, rail, and marine transportation. The majority of emissions are a result of highway vehicles which can be further broken down into vehicle and fuels type. The greatest contributor to highway vehicle emissions are gasoline passenger cars. However, although medium/heavy duty vehicles account for 20 percent of GHG emissions, they represent an estimated 40 percent of particulate matter. Accordingly, while these medium and heavy-duty vehicles represent a smaller number of vehicles, they have a disproportionately larger impact on air quality emissions and health outcomes compared to the sector at large.

In 2022, Massachusetts aligned with California regulations, including the Advanced Clean Trucks and Advanced Clean Cars II regulations for 2025-2035 Model Years, which should propel a more rapid level of adoption of zero emissions vehicles.

Further, based on feedback received from the engagement process it is noted that stakeholders were strongly supportive of a focus transportation, with a special focus on fleet electrification for medium- and heavy-duty vehicles. In particular, community-based organizations centered on environmental justice identified both the health and noise impacts of reducing medium- and heavy-duty vehicle traffic in their neighborhoods and also the economic impacts. One organization identified that often the owners of fleets garaged in LIDAC communities are owned by people or corporations not resident within those communities, reflecting an alienation of decisions about those fleets from the impacts the fleets have in particular neighborhoods. A number of organizations suggested that the engagement already underway through the PCAP can help to identify locally owned fleets which should be a focus of investment. Separately, corporate environmental stakeholders, such as Ceres, which operates the Corporate Electric Vehicle Alliance provided strongly supportive feedback for transportation focused measures focused on medium- and heavy-duty vehicles, identifying the higher upfront costs, lack of available public charging infrastructure, and limited model configuration diversity and unit volume for zero-emission medium- and heavy-duty vehicles as barriers that a program focused on fleet electrification can address. In addition, some stakeholders were strongly supportive of transportation alternatives, such as electric bicycles.

T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles

Measure Detail

Adopting zero emission medium- and heavy-duty vehicles will reduce tailpipe emissions on roadways, throughout neighborhoods, and at loading areas by transitioning gasoline and diesel vehicles to electric alternatives. Statewide, transportation represents the largest source of GHG emissions. The transition to electric transportation will also result in significant co-benefits, including locally reduced criteria and toxic air pollutants with associated improved health outcomes, reduced noise, and economic benefits from lower burdens to public health care systems. Implementation concepts will focus on vehicle procurement, updating fueling/charging infrastructure and supporting educational/operational changes, vehicle incentives and investments in workforce development.

The reduction of medium and heavy-duty vehicle emissions has one of the most significant impacts on local environmental health. EPA research from communities immediately adjacent to roadways has shown higher exposure to air pollutants and associated health impacts like increased rates of asthma and heart disease.[41] Several studies have looked at the air quality and health benefits of vehicle electrification. According to one 2023 study, electrifying 30% of heavy-duty vehicles over the region surrounding North America's largest freight hub, Chicago, "has robust air quality and health benefits, including reduced NO2 and concentrations and associated health benefits, reduced air PM2.5 pollution disparities among population subgroups, and reduced CO2 emissions."[42]

Implementation Concepts

- **Medium-duty vehicles** (Class 3-6, 10,001 – 26,000 lbs.): Increase adoption of electric transit and delivery vans, trucks, transit and school buses, and other vehicle types through vehicle incentives, charging infrastructure support, garage infrastructure upgrades, workforce development and technical assistance.
- **Heavy-duty vehicles** (Class 7-8, 26,001 – 33,000 lbs.): Increase adoption of electric school and transit buses, trucks, and other vehicle types through vehicle incentives, charging infrastructure support, garage infrastructure upgrades, workforce development and technical assistance.

GHG Reduction Estimate

Table 7: T1 GHG Reduction Estimate

Projected annual reduction in 2030:	**0.14 $MMTCO_2e$**

[41] EPA. Research on Near Roadway and Other Near Source Air Pollution. https://www.epa.gov/airresearch/research-near-roadway-and-other-near-source-air-pollution

[42] Camilleri, S. F., et al. (2023). Air quality, health and equity implications of electrifying heavy-duty vehicles. Nature Sustainability, 6,1643-1653. https://doi.org/10.1038/s41893-023-01219-0

Cumulative reduction 2025 – 2030:	0.30 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (no further adoption)	3.35 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (continued adoption)	13.99 $MMTCO_2e$

This reduction measure is calculated by 1) Using Massachusetts Vehicle Census and VMT data for medium and heavy duty vehicles from January 2020 2) Calculating annual gallons of diesel and gasoline by assuming average fuel economies 3) Calculating baseline M/HD vehicle emissions using EPA 2020 emissions factors for medium- and heavy-duty diesel and gasoline vehicles 4) Use assumed electrical vehicle efficiency values for each electric vehicle type to calculate electricity use for VMT 5) Calculate avoided emissions based on difference between baseline and electric emissions. 6) Project to 2050 under no further adoption (after 2030) and continued adoption (until 2050) scenarios using annual linear rates that roughly align with horizon year CECP targets for 2030 and 2050.

Calculations assume the following activity by 2030:

- 10% of combustion engine medium- and heavy-duty vehicles convert to all-electric vehicles by 2030 occurring in equal number of vehicles in each year of 2027, 2028 and 2029 (3.3% per year), accounting for limited initial lag in implementation effect due to typical vehicle end of life.
- At end of useful life, all converted electric vehicles would be replaced with similar zero tail-pipe emissions vehicles for cumulative reductions with continued adoption.

Projected Reduction in 2030 GHG Inventory: 0.14 $MMTCO_2e$, 0.46% of Transportation sector emissions and 0.20% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 3.35 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050, excepting slight variance in CH_4 and N_2O emissions due to shifting annual EPA mobile combustion factors for gasoline vehicles. This reduction measure is calculated by holding the 10% electrification in 2030 constant until 2050. The same procedure and sources as listed above are followed for each consecutive year to 2050 with the projected electrification values, and cumulative reductions are calculated.

Calculations assume the following activity by 2050:

- 10% of combustion engine medium- and heavy-duty vehicles convert to all-electric vehicles by 2030 with all fleet conversion occurring in equal number of vehicles in each year of 2027, 2028 and 2029 (3.3%/year).
- No additional fleet conversion beyond 2030, with 10% conversion of combustion engine medium- and heavy-duty vehicles remaining in 2050.

Cumulative Reduction to 2050 (continued adoption): 13.99 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050, excepting slight variance in CH_4 and N_2O emissions due to shifting annual EPA mobile combustion factors for gasoline vehicles. This reduction measure assumes a continued trajectory of implementation based on the annual rate of change from 2027-2030 (3.3%/year). This results in 76.7% fleet conversion in 2050, roughly aligning with the 2050 CECP target. The same procedure and sources as listed above are followed for each consecutive year to 2050 with the projected electrification values, and cumulative reductions are calculated. The calculations assume the following activity by 2050:

- 76.7% of combustion engine medium- and heavy-duty vehicles convert to all-electric by 2050 with 3.3% fleet electrification per year from 2030 to 2050.
- At end of useful life, all converted electric vehicles would be replace with similar zero tail-pipe emissions vehicles for cumulative reductions with continued adoption.

Impact to Low Income and Disadvantaged Communities

Highways and arterials often pass through low income and disadvantaged communities. In addition, many medium- and heavy-duty vehicle fleets are garaged in LIDAC communities and travel through neighborhoods on their routes. Accordingly, the benefits of this program will be particularly critical for those communities that are most heavily impacted by the existing freight distribution system, including communities near highways, warehouses, ports such as Conley Terminal, and Logan Airport. These communities will enjoy cleaner air, improved health outcomes, and reduced noise. Benefits of this measure include public health outcomes for abutters, such as fewer asthma attacks, hospital visits, preventable deaths, and health care cost savings, as well as reduced noise, as electric trucks produce half the noise pollution of diesel vehicles.

One of the key challenges to medium- and heavy-duty fleet conversion is the high upfront cost of vehicles, and the lack of electric vehicles for customers in the used vehicle market. This may be particularly felt for small business owners relying on medium-duty delivery vehicles, for example.

Accessible charging infrastructure, accessible vehicle rebates, and intentional local community planning are all key aspects to measure implementation to ensure benefits are realized in low income and disadvantaged communities.

Beyond the direct impacts, the goal is that this program will inspire fleet operators to expand investments in vehicle electrification. Communication will continue with fleet operators to assess their experience with the first round of procurement and encourage full fleet electrification. Targeted outreach to fleets focused in LIDACs can spur investment in these communities and the development of skills and high-paying jobs. Success with these early adopters will help electric vehicles achieve wider penetration, supporting the compulsory regulations of the Advanced Clean Truck rule and the transition of the whole vehicle fleet to zero-emission vehicles.

T2. Adopt Zero Emission Light-Duty Vehicles

Measure Detail

Adopting zero emission light-duty vehicles will reduce tailpipe emissions on roadways and throughout neighborhoods by transitioning gasoline vehicles to electric vehicles. The transition will result in locally cleaner air, reduced noise, and improved health outcomes. Statewide, transportation represents the largest source of GHG emissions. Implementation concepts will focus on vehicle procurement, updating fueling/charging infrastructure and supporting educational/operational changes.

Implementation Concepts

- **Passenger vehicles** (Class 1, up to 6,000 lbs.): Accelerate the adoption of zero tailpipe emission vehicles through rebates, vehicle procurement, and charging infrastructure development.
- **Light Duty vehicles** (Class 2, 6,001 – 10,000 lbs.): Accelerate the adoption of electric vehicles to replace light-duty trucks through vehicle incentives, charging infrastructure support, and technical assistance.

GHG Reduction Estimate

Table 8: T2 GHG Reduction Estimate

Projected annual reduction in 2030:	**2.00 $MMTCO_2e$**
Cumulative reduction 2025 – 2030:	4.00 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (no further adoption)	43.96 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (continued adoption)	155.87 $MMTCO_2e$

This reduction measure is calculated by 1) Using Massachusetts vehicle census and VMT data for passenger and light duty vehicles from January 2020 2) Calculating annual gallons of gasoline by assuming average fuel economy 3) Calculating baseline passenger and light duty vehicle emissions using EPA 2020 emissions factors for passenger and light duty gasoline vehicles 4) Use assumed electrical vehicle efficiency values for passenger electric vehicles to calculate electricity use for VMT 5) Calculate avoided emissions based on difference between baseline and electric emissions. 6) Project to 2050 under no further adoption (after 2030) and continued adoption (until 2050) scenarios using annual linear rates that roughly align with horizon year CECP targets for 2030 and 2050.

Calculations assume the following activity by 2030:

- 15% of gasoline-powered passenger and light-duty vehicles convert to all-electric vehicles by 2030 occurring in equal number of vehicles in each year of 2027, 2028 and 2029 (5% per year), accounting for limited initial lag in implementation effect due to typical vehicle end of life.
- At end of useful life, all converted electric vehicles would be replaced with similar zero tail-pipe emissions vehicles for cumulative reductions with continued adoption.

Projected Reduction in 2030 GHG Inventory: 2.00 $MMTCO_2e$, 6.51% of Transportation sector emissions and 2.80% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 43.96 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050, excepting slight variance in CH_4 and N_2O emissions due to shifting annual EPA mobile combustion factors for gasoline vehicles. This reduction measure is calculated by holding the 15% electrification in 2030 constant until 2050. The same procedure and sources as listed above are followed for each consecutive year to 2050 with the projected electrification values, and cumulative reductions are calculated.

Calculations assume the following activity by 2050:

- 15% of gasoline-powered passenger and light-duty vehicles convert to all-electric vehicles by 2050 with all fleet conversion occurring in equal number of vehicles in each year of 2027, 2028 and 2029 (5%/year).
- No additional fleet conversion beyond 2030, with 15% conversion of gasoline-powered passenger and light-duty vehicles remaining in 2050.

Cumulative Reduction to 2050 (continued adoption): 155.87 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050, excepting slight variance in CH_4 and N_2O emissions due to shifting annual EPA mobile combustion factors for gasoline vehicles. This reduction measure assumes 4% electrification per year from 2030 to 2050, resulting in 95% fleet conversion in 2050, roughly aligning with the 2050 CECP target. The same procedure and sources as listed above are followed for each consecutive year to 2050 with the projected electrification values, and cumulative reductions are calculated.

Calculations assume the following activity by 2050:

- 95% of gasoline-powered passenger and light-duty vehicles convert to all-electric by 2050 with 4% fleet electrification per year from 2030 to 2050.
- At the end of useful life, all converted electric vehicles would be replace with similar zero tail-pipe emissions vehicles for cumulative reductions with continued adoption.

Impact to Low Income and Disadvantaged Communities

Residents of low income and disadvantaged communities face significant barriers to transitioning to electric transportation, including the high upfront cost of the vehicles and the difficulties accessing charging for renters and residents of dense urban areas. Making the electric vehicle transition work for low income and disadvantaged communities is going to require targeted policies, smart planning, and partnerships with community organizations on the ground to be effective.

Massachusetts is moving forward with a number of programs specifically focused on making electric vehicles work for residents of LIDAC communities, including providing incentives for used EVs, providing increased incentives for low-income residents and vehicle for hire drivers, and supporting charging infrastructure in apartment buildings and on the street.

By making electric vehicles available and affordable for more Massachusetts residents, we will ensure that residents of LIDAC communities get the benefits of electric vehicles, including reduced operating and maintenance costs and reduced local particulate matter and nitrous oxide emissions.

Highways and arterials often pass through low income and disadvantaged communities; thus, the benefits of this program will be particularly great for those communities that are most heavily impacted by the existing passenger roadway system, including communities near highways, major employment destinations, and Logan Airport. These benefits are particularly advantageous to positively impact CEJST Health and Transportation burdened communities. These communities will enjoy cleaner air, improved health outcomes, and reduced noise. Benefits of this measure include public health outcomes for abutters, such as fewer asthma attacks, hospital visits, preventable deaths, health care cost savings, and reduced noise.

Specific challenges related to light-duty vehicle electrification also impact LIDAC communities. First, although new EVs are approaching cost parity with internal combustion vehicles, drivers who are purchasing in the used vehicle market often have access to fewer and more expensive electric vehicles. This can lead to slower uptake for low- and moderate-income residents, and therefore a slower increase in the benefits noted above to result for vehicle electrification. Some residents will also face obstacles related to EV charging, including tenants, residents in multifamily housing, and those who do not have off-street parking access. Finally, the total cost of ownership of electric vehicles requires clear education and communication and depends upon understanding the near-term and long-term value of capital and savings to diverse groups of customers.

Public charging, accessible vehicle rebates, and intentional local community planning are all key aspects to measure implementation to ensure benefits are realized in low income and disadvantaged communities.

T3. Increase Alternatives to Personal Vehicle Use

Measure Detail

Increasing access to transportation options will provide opportunities for personal vehicle drivers and riders to more frequently choose other, greener, modes of transportation. In Massachusetts, 52 percent of all trips are three miles or fewer – a typical biking distance for many people (about 16 minutes) – and yet 80 percent of those trips are currently made in vehicles[43]. While Massachusetts residents make just 1.4% of their daily trips by bike (e.g., work, school, shopping, or other routine activities), communities that have invested in high-comfort bikeways and fostered a culture of active transportation are seeing among the highest bike commute rates in the country: Hatfield (4.7%), Amherst (5.0%), Somerville (5.9%), Cambridge (7%), and Provincetown (8.9%). Additionally, access to rail transit is critical for expanding economic opportunity throughout the Commonwealth, and for reducing longer trips. Connected networks of safe, comfortable, and convenient bikeways and rail transit enhance mobility, public health, environmental sustainability, and economic development opportunities. Reducing miles traveled by vehicles is one of the most effective means to reduce transportation emissions and also reduces the need for charging infrastructure and energy demand. According to a 2022 update to the 2019 Massachusetts Bicycle Plan, areas of western Massachusetts along Route 7 and Cape Cod along Route 6 are particularly opportune for "everyday biking."

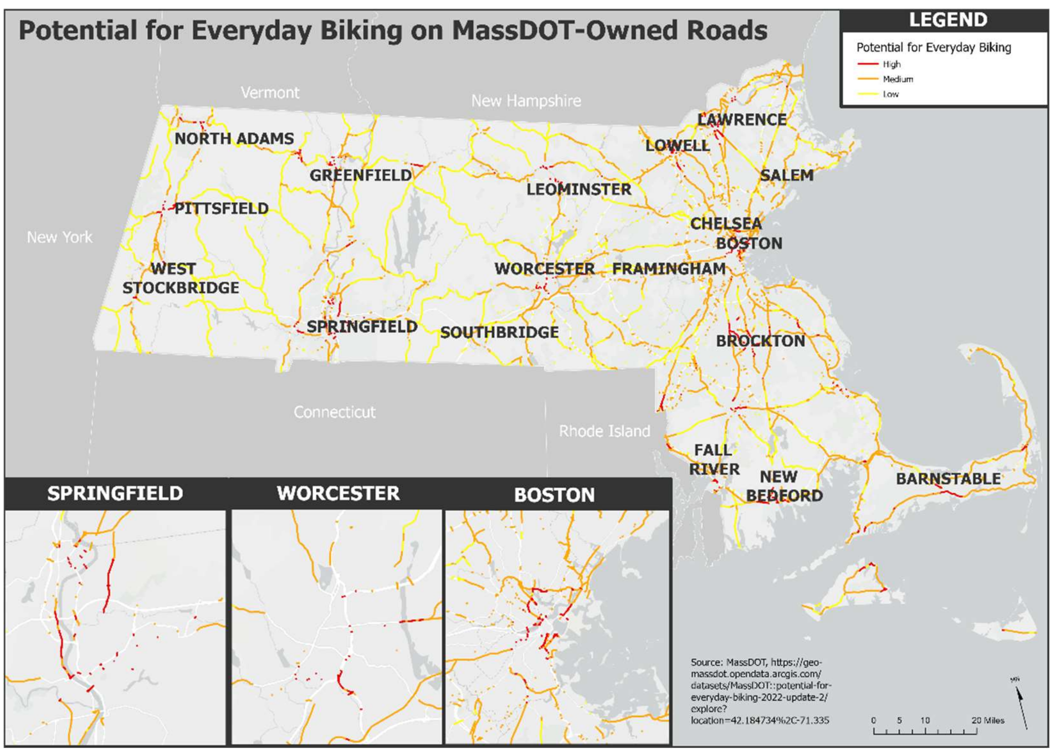


Figure 14: Potential for Everyday Biking Map

[43] Massachusetts Bicycle Transportation Plan (arcgis.com)

Commuter rail, transit and alternative transportation, such as bicycles, work best when they are coordinated with each other. When well connected, biking and transit are highly complementary travel modes. People living too far to conveniently walk to transit may still be within a quick bike ride to a station or stop, closing the "first and last mile gap" and expanding the number of households that can access transit. Providing the option to bike to transit can encourage ridership growth while simultaneously managing both congestion and demand for additional parking. Many RTAs have taken steps to integrate bikes and transit, but access can be space and time-restricted. Bus stops and rail stations are more accessible to people biking when they offer amenities such as secure bike parking, wayfinding signs, and high-comfort access routes. Bike racks on buses, now standard on Massachusetts Bay Transportation Authority (MBTA) and regional transit authorities (RTA) buses throughout Massachusetts, provide even greater access by allowing a traveler to bike at both ends of their trip

Implementation Concepts

- **Increase short-distance transportation alternatives**: Increase access to passenger van service, e-bikes, ride-share programs, and investments in safe road/rail infrastructure for modes of travel alternatives to passenger vehicles.
- **Expand and electrify rail service**: Increase service for rapid transit, commuter rail, regional rail and accelerate the implementation of West-East Rail by investing in rail and station upgrades, electrification, schedule/trip expansion, with focus on station and rail resiliency for service continuity.
- **Support transit-oriented development and smart growth**: Increase support for complete street design that encourages pedestrian and bike use and community development in which people can get around without a car, such as municipal and regional planning, zoning and incentives that expand housing production near transit hubs.

GHG Reduction Estimate

Table 9: T3 GHG Reduction Estimate

Projected annual reduction in 2030:	**0.40 MMTCO_2e**
Cumulative reduction 2025 – 2030:	1.19 MMTCO_2e
Cumulative reduction 2025 –2050: (no further adoption)	9.12 MMTCO_2e
Cumulative reduction 2025 – 2050: (continued adoption)	25.78 MMTCO_2e

This reduction measure is calculated by 1) establishing a single occupant vehicle emissions baseline from VMT 2) calculate avoided emissions from mode-shift to zero emission options.

Calculations assume the following activity by 2030:

- 3% reduction in passenger vehicle emissions in 2030 due to mode shift adoption with mode shift adoption occurring in equal intervals from 2025 to 2030 (0.6%/year).

Projected Reduction in 2030 GHG Inventory: 0.40 $MMTCO_2e$, 1.29% of Transportation sector emissions and <1% of total emissions compared to 2019 baseline.

Cumulative GHG Reduction to 2050 (no further adoption): 9.12 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This reduction measure assumes the measure adoption increases 0.60%/year starting in 2025, until the fleet reaches the prescribed 3% adoption threshold in 2030. 3% adoption is then held constant until 2050. The same procedure listed above is followed for each consecutive year to 2050 with the projected emission values, and cumulative reductions are calculated.

Calculations assume the following activity by 2030:

- 3% reduction in passenger vehicle emissions in 2030 due to mode shift adoption with mode shift adoption occurring in equal intervals from 2025 to 2030 (0.6%/year).
- No additional mode shift adoption beyond 2030, with 3% adoption remining in 2050.

Cumulative GHG Reduction to 2050 (continued adoption): 25.78 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This reduction measure assumes a continued trajectory of implementation from 2025 to 2050T at 0.6%/year. The same procedure listed above is followed for each consecutive year to 2050 with the projected emission values from the increased use of multimodal transportation, and cumulative reductions are calculated.

The calculations the following activity by 2050:

- 15% reduction in passenger vehicle emissions in 2050 due to mode shift adoption with mode shift adoption occurring in equal intervals from 2025 to 2050 (0.6%/year).

Impact to Low Income and Disadvantaged Communities

Residents of Low Income and Disadvantaged Communities (LIDAC) stand to benefit significantly from investments that we make in public transportation, housing and transit-oriented development, and bike and pedestrian infrastructure. For many residents, public transportation is a critical lifeline connecting people to jobs and opportunities. Investments we make in housing near public transportation hubs can help residents afford to live in areas with strong transportation services. And improvements in bike and pedestrian infrastructure can help residents feel safe riding a bike or walking along roadways.

Increasing transportation reliability and reducing travel time will benefit LIDACs by providing increased travel options for passengers to reach jobs. Expanding the multimodal network can occur in areas with access to commuter rail stops which increases economic opportunities, essential services, and educational opportunities via increased transit access. These benefits are particularly advantageous to positively impact CEJST Transportation burdened communities. Additionally, increased active Transportation has major health and safety benefits.

Potential disbenefits include increased traffic in areas with transit stations. Temporarily, impacts may include noise and pollution from construction necessary to expand existing transit access. Additionally, increased transit access can result in increased property value, which has benefits for some, but can also exacerbate housing affordability.

Buildings

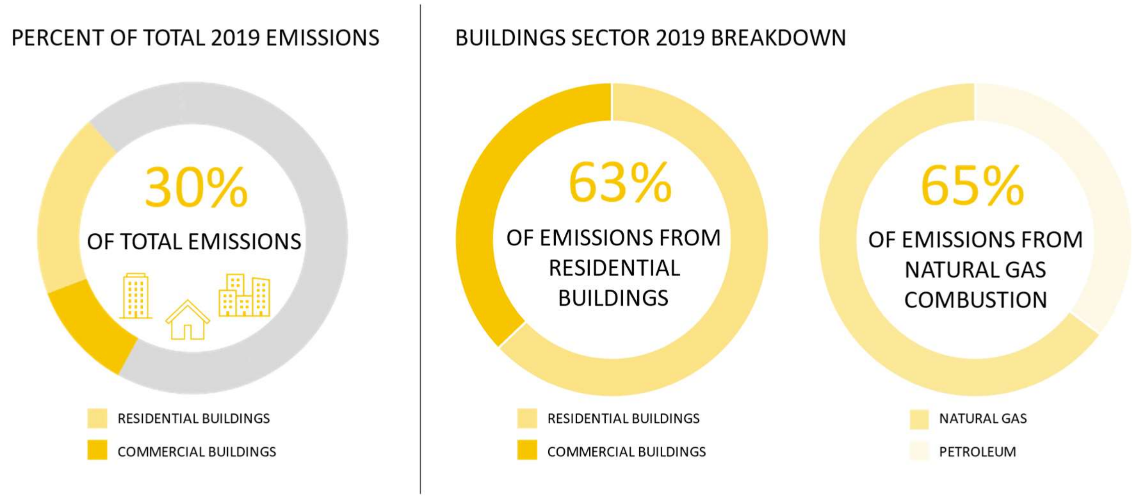


Figure 15: Buildings Sector 2019 Emissions

The Buildings sector in Massachusetts has over two million individual buildings across a range of vintages, owners, occupants and systems. In this climate, space heating is a major energy demand in buildings. Approximately 50 percent of all residential households in Massachusetts use pipeline gas for space heating, just under a third use delivered fuel oil or propane, and about 15 percent use electricity for electric resistance heating and air-source or ground-source heat pumps. About 75 percent of commercial square footage in Massachusetts is heated with natural gas, while petroleum, electricity, and district steam systems comprise the remainder. Emissions from fuel combustion in buildings has generally trended downward with progressive energy codes driving better efficiency and insulation, yet volumetric rates for natural gas are currently less than comparable electricity rates under current rate design, creating demand for these systems.

As an accounting convention adopted by the Commonwealth in 2009, the GHG emissions from the Buildings sector covers Scope 1 emissions from the combustion of fossil fuels on-site for space and water heating and other uses. Scope 2 emissions associated with electricity usage are reported in the Electric Power sector. Reducing emissions from residential and commercial buildings ultimately hinges upon reducing total energy demand through efficiency measures and transitioning building heating demands away from fossil fuels and toward electricity. Emissions from on-site combustion in residential and commercial buildings in Massachusetts remain a significant contributor to the state's overall GHG emissions profile, making up 30 percent of total emissions. To effectively address emissions from on-site combustion in residential and commercial buildings, the priority action measures focus on energy efficiency and electrification that can accelerate the transition to cleaner, more efficient, and sustainable building energy systems.

The following table shows the 1990 historical GHG emissions and sector sub limits from the 2025/2030 and 2050 CECPs for the Building sector. These values provide context for the overall GHG emissions reductions that can be expected from this sector during the periods 2025-2030 and 2025-2050.

Sector	1990	2025	2030	Difference 2025-2030	2050	Difference 2025-2050
Buildings (residential and commercial)	23.8	17.2	12.5	-4.7	1.7	-15.5

Further, stakeholders recognized the need for continued investment in the Building sector decarbonization. A number of community-based organizations active in affordable housing and energy justice identified structural issues which must still be addressed in order to make building electrification beneficial for affordable housing tenants. Those issues include the existing differential in volumetric pricing between electricity and natural gas in which air source heat pumps have the potential to add operating costs to tenants. The second issue is the prospect that electrification will shift the cost of winter heating from landlord-owned central furnaces to tenant-metered electric heat pumps.

B1. Increase Building Efficiency

Measure Detail

Appliance and building envelope efficiency are typically cost-effective tools to reduce GHG emissions in buildings and lower utility bills. Building retrofits to improve the enclosure and envelope with better insulation and air sealing reduce energy use intensity. These weatherization projects in colder climates such as Massachusetts traditionally realize significant energy and carbon emission savings while helping to reduce peak electricity demands. Additional efficiency measures such as LED lighting replacement, low flow / ultra-low flow hot water fixture replacement and high efficiency appliance replacement are minimally invasive projects that can provide significant savings. Together, these actions can help limit the GHG emissions from buildings.

Implementation Concepts

- **Renovate/retrofit existing commercial buildings:** Assist municipal governments and commercial building owners/operators with energy efficiency analysis and implementation of commercial building energy reduction programs.
- **Renovate/retrofit existing housing stock:** Assist residential building owners/operators with energy efficiency analysis and implementation of recommended measures.
- **Renovate/retrofit existing schools:** Assist schools and state colleges and universities, through multiple actions for energy efficiency. Include a focus on curriculum and community engagement to maximize community learning and awareness of decarbonization efforts.

GHG Reduction Estimate

Table 10: B1 GHG Reduction Estimate

Projected annual reduction in 2030:	**1.42 MMTCO$_2$e total** 1.07 MMTCO$_2$e – Scope 1 0.27 MMTCO$_2$e – Scope 2
Cumulative reduction 2025 – 2030:	5.36 MMTCO$_2$e
Cumulative reduction 2025 – 2050: (no further adoption)	41.10 MMTCO$_2$e
Cumulative reduction 2025 – 2050: (continued adoption)	69.17 MMTCO$_2$e

This reduction measure is calculated by 1) establishing a building emissions baseline based on sf of residential and commercial buildings 2) calculate energy efficiency savings per square foot based on NREL Slope data for natural gas and electricity 3) calculate energy savings based on percent of buildings that implement measures, assuming that percent of buildings equates to percent of building square footage 4) convert energy savings to emissions reduction 5) calculate avoided emissions from applicable building type baseline.

Calculations assume the following activity by 2030:

- 28% of all commercial buildings, including municipal buildings and schools, implement retrofits.
- 24% of single family homes & residential buildings implement retrofits.

Projected Reduction in 2030 GHG Inventory: 1.07 $MMTCO_2e$ from Scope 1, 4.93% of Building sector emissions; and 0.27 $MMTCO_2e$ from Scope 2, 2.51% of Power sector emissions; and 1.9% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 41.10 $MMTCO_2e$

These building efficiency measure adoptions increase every year from 2025, until the prescribed adoption thresholds are met by 2030:

- 28% of all commercial buildings, including municipal buildings and schools, implement retrofits.
- 24% of single family homes & residential buildings implement retrofits.

These percent adoptions are then held constant until 2050.

Cumulative Reduction to 2050 (continued adoption): 69.17 $MMTCO_2e$

This reduction measure assumes a continued trajectory of implementation based on the average annual rate of change from 2025-2030 until 63% implementation is reached in 2050 for all commercial, residential, school, and municipal buildings.

Impact to Low Income and Disadvantaged Communities

Benefits of this measure will be felt across the Commonwealth through 30 percent lower energy costs and cost stabilization. Current energy-inefficiency in buildings can result from older appliances or a lack of insulation in older homes. For residents of older buildings who face these challenges, there is an even greater opportunity for cost savings through energy efficiency. As discussed in detail in the workforce planning analysis section, energy efficiency is the area with the greatest potential for job growth across all clean energy sectors.

B2. Decarbonize Building Heating Systems

Measure Detail

Decarbonizing building systems for space and water heating requires replacement of traditional combustion equipment with options that exclude end-use combustion of fossil fuels, such as electric air source and ground source heat pumps and heat pump water heaters. Current systems emit a large quantity of greenhouse gases, especially in larger commercial buildings. While electrification of new development can be addressed through building codes, decarbonization of existing buildings with older equipment requires a combination of performance standards, equipment standards, clean heating standards, and/or targeted incentives for replacement of equipment either at the equipment's end of life or sooner. Together, these actions can help reduce the GHG emissions from buildings.

Implementation Concepts

- **Increase heat pump adoption:** Promote the transition to efficient residential air source heat pumps and heat pump water heaters through supporting the supply chain for available and affordable heat pumps, collecting data on installation costs, investing in technical support and workforce development for installation, and increasing customer awareness and residential demand.
- **Expand geothermal adoption:** Expand implementation of ground source heat pumps and networked geothermal at residential and commercial building scale.

GHG Reduction Estimate

Table 11: B2 GHG Reduction Estimate

Projected annual reduction in 2030:	**4.26 MMTCO_2e** 4.35 MMTCO_2e – Scope 1 (0.08) MMTCO_2e – Scope 2
Cumulative reduction 2025 – 2030:	12.62 MMTCO_2e
Cumulative reduction 2025 – 2050: (no further adoption)	96.79 MMTCO_2e
Cumulative reduction 2025 – 2050: (continued adoption)	124.80 MMTCO_2e

This reduction measure is calculated by 1) establishing a building emissions baseline based on square-footage of residential and commercial buildings 2) calculate energy efficiency savings from high performance heat pump solutions 3) convert energy savings to emissions reduction 4) calculate avoided emissions from applicable building type baseline for displacing natural gas, propane, and fuel oil heating.

Calculations assume the following activity by 2030:

- 20% of housing units electrify with high performance air-source heat pumps for space and water heating
- 24% of commercial buildings electrify with high performance air-source heat pumps for space and water heating
- 4.5% of housing units electrify with geothermal heat pumps
- 4% of commercial buildings electrify with geothermal heat pumps

Projected Reduction in 2030 GHG Inventory: 4.35 $MMTCO_2e$ reduction in Scope 1 emissions, 20% reduction of Building sector emissions; 0.08 $MMTCO_2e$ increase in Scope 2 emissions, 0.8% increase in Power sector emissions; and 5.95% reduction of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 96.79 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the air-source heat pump for space heating and heat pump water heater adoption for commercial buildings increases by 24% from 2025-2030 and is then held constant until 2050. This measure also assumes that geothermal heat pump adoption in commercial buildings increases by 4% from 2025-2030 and is then held constant until 2050.

For residential buildings, this measure assumes air-source heat pump for space heating and heat pump water heater adoption for residential buildings increases by 20% from 2025-2030 and is then held constant until 2050. This measure also assumes geothermal heat pump adoption for residential buildings increases by 4.5% from 2025-2030. 4% geothermal adoption is then held constant until 2050.

Cumulative Reduction to 2050 (continued adoption): 124.80 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the air-source heat pump for space heating and heat pump water heater adoption for commercial buildings increases by 24% from 2025-2030, and then increases linearly from 24% adoption in 2030 to 59.01% adoption in 2050. This calculation also assumes geothermal heat pump adoption in commercial buildings increases by 4% from 2025-2030, and then increases linearly from 4% adoption in 2030 to 4.38% adoption in 2050.

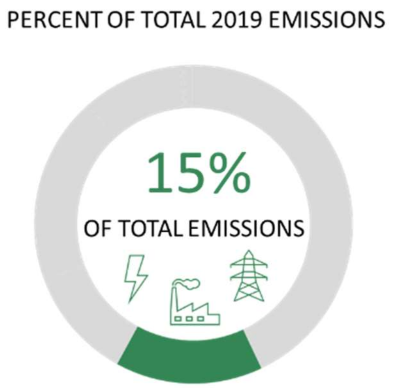
For residential buildings, this measure assumes air-source heat pump for space heating and heat pump water heater adoption for residential buildings increases by 20% from 2025-2030, and then increases linearly from 20% adoption in 2030 to 66.7% adoption in 2050. This measure also assumes geothermal heat pump adoption for residential buildings increases by 4.5% from 2025-2030, and then increases linearly from 4.5% adoption in 2030 to 5% adoption in 2050.

Impact to Low Income and Disadvantaged Communities

Home heat pumps are cost competitive for customers who rely on delivered fuels for home heating. For customers converting from gas heat to electric heating systems, electric heat can be more expensive than current gas heating costs. Gas and electric rate pricing are expected to change over time through utility rate proceedings, but there remains a risk of overburdening electric heating customers in the near term, and overburdening gas customers in the longer-term who do not make the transition to clean heat. Additionally, converting from gas or oil heat to electric heat for multifamily housing can, in some cases, also shift costs from the landlord (central heating bill) to residents (per unit electricity bills), which must be addressed and managed through grid meter upgrades and policy solutions. Local community planning, engagement with environmental justice communities, utility rate structure adjustments, and financial assistance programs are key aspects of program implementation to ensure benefits are realized in low income and disadvantaged communities.

Further benefits of heat pump installation include the addition of air conditioning in buildings, which is increasingly becoming a necessity across Massachusetts due to hotter summer temperatures and improved indoor air quality. Lastly, as the transition to clean heat must happen in every community across the Commonwealth, local workforce growth opportunities are widespread. Strategies and opportunities for workforce development for clean heat and building upgrades are detailed in Workforce Planning Analysis.

Power



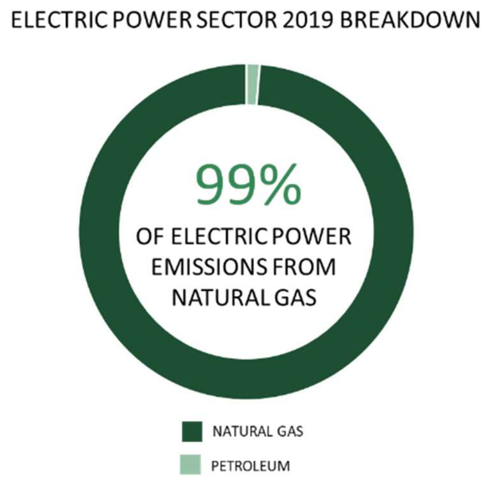


Figure 16: Power Sector 2019 Emissions

The Power Sector makes up 15 percent of the overall emissions in Massachusetts. These GHG emissions include in-state generation of electricity and imported electricity from other states. The use of electricity to heat and cool buildings and vehicle charging in Massachusetts is included within this sector. The power sector in Massachusetts consists of generation assets that rely on a mix of fossil fuels, and renewables and imported hydroelectric power. Natural gas-fired power plants are a major source of electricity generation in Massachusetts. Given that the power sector uses both in-state and imported electricity, the Massachusetts emissions factor for electricity, 412 $lbCO_2e/MWh$, is calculated using MA-based emissions rates after accounting for generation information system (GIS) certificates.

The following table shows the 1990 historical GHG emissions and sector sub limits from the 2025/2030 and 2050 CECPs for the Power sector. These values provide context for the overall GHG emissions reductions that can be expected from this sector during the periods 2025-2030 and 2025-2050.

Sector	1990	2025	2030	Difference 2025-2030	2050	Difference 2025-2050
Electric Power	28.2	13.2	8.4	-4.8	2.0	-11.2

The priority reduction measures focus on expanding renewable energy and maximizing the utilization of clean energy through investments in electric utility infrastructure, with the goal of achieving the state's ambitious climate goals and transitioning to a decarbonized power system.

Expanding distributed generation in Massachusetts, as elsewhere, is subject to significant constraints of interconnection with the existing electric distribution system. Interconnection is the process of connecting a distributed generation system to the electric grid. Prior to connecting, the distributed generation system owner must obtain written approval from the local utility in the form of an Interconnection Service Agreement. Although Massachusetts electric utilities have made Hosting Capacity Maps available for review by renewable energy developers to guide development to those locations with sufficient grid capacity, delays and unpredictability continue to add cost to renewable energy projects and to discourage development.

The potential impact of interconnection delays and the need for investment in modernization of the electric grid is underscored by the transition to electric appliances for home heating and to electric vehicles. In addition to incentives for federal and state incentives for electric vehicles, federal tax credits for home efficiency upgrades, and state energy efficiency and electrification programs, recent regulatory changes have also underscored the importance of grid modernization for decarbonization. For example, the projected growth of networked geothermal systems based on pilot programs authorized by the Department of Public Utilities and encouraged by the 20-80 Order on gas systems, will increase demand for electric load for heat, not just interconnection for renewable energy projects.[44]

Further, stakeholders articulated general support for the needed investment in decarbonization of the power sector. Although the need for renewables development was widely agreed upon, for some community-based organizations, the scale and location of large-scale renewable development made those investments of less immediate interest. Workforce development, resilience, and economic opportunities significantly increased the importance of these measures for some groups of stakeholders, including organized labor and community-based organizations.

[44] Department of Public Utilities Issues Order 20-80 | Mass.gov

P1. Develop New Renewable Energy Facilities

Measure Detail

The development of new renewable energy facilities in Massachusetts is vital for achieving clean energy goals, reducing carbon emissions, and ensuring a sustainable and resilient energy future for the state. Relying on a diverse set of renewable energy sources, such as wind, solar, and geothermal helps Massachusetts create a resilient and sustainable energy portfolio and speed the transition away from carbon-intensive energy generation. Diversification also enhances energy security and reduces vulnerability to supply disruptions.

Implementation Concepts

- **Accelerate offshore wind development:** Invest in port infrastructure to support offshore wind development and overcome supply chain bottlenecks. Focus on opening new offshore wind areas, such as the Gulf of Maine.
- **Increase solar PV development:** Assist utility and community scale solar deployment, through technical assistance and incentives.

GHG Reduction Estimate

Table 12: P1 GHG Reduction Estimate

Projected annual reduction in 2030:	**5.05 $MMTCO_2e$**
Cumulative reduction 2025 – 2030:	18.71 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (no further adoption)	120.52 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (continued adoption)	327.83 $MMTCO_2e$

This reduction measure is calculated by 1) establishing an electric power emissions baseline 2) calculate clean energy generation from CECP 2030 targets 3) convert energy generation to emissions savings 4) calculate avoided emissions from power sector baseline for displacing fossil fuel electricity generation with renewable energy sources.

Calculations assume the following activity by 2030:

- 13 TWh of solar, 13 TWh of offshore wind, and 1 TWh of onshore wind

Projected Reduction in 2030 GHG Inventory: 5.05 $MMTCO_2e$, 47% of Power sector emissions and 7% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 120.52 $MMTCO_2e$ total: 59.06 $MMTCO_2e$ from solar, 55.88 $MMTCO_2e$ from offshore wind, 5.59 $MMTCO_2e$ from onshore wind.

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the measure adoption does not increase after 2030. The 13 TWh of solar, 13 TWh of offshore wind, and 1 TWh of onshore are maintained through 2050.

Cumulative Reduction to 2050 (continued adoption): 327.83 $MMTCO_2e$ total: 125.44 $MMTCO_2e$ from solar, 195.22 $MMTCO_2e$ from offshore wind, and 7.18 $MMTCO_2e$ from onshore wind.

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes a continued trajectory of implementation based on the CECP "phased" 2050 targets: 46 TWh of solar, 84 TWh of offshore wind, and 2 TWh of onshore wind. This assumes a constant annual rate of change from 2030-2050.

Impact to Low Income and Disadvantaged Communities

Investing in new renewable energy facilities stimulates economic growth by attracting investments and creating jobs across the supply chain. This includes manufacturing, installation, maintenance, and associated services related to renewable energy projects. Investing in renewable energy projects also often brings community and environmental benefits, including improved air and water quality, reduced noise pollution, and support for local ecosystems.

Local disbenefits related to investing in port infrastructure include impacts associated with increased construction, including noise, dust, and traffic around the port site.

Regarding solar and onshore wind development, public engagement in energy infrastructure siting and permitting processes is an essential part of measure implementation. Additionally, data-informed planning, such as utilizing DOER's 2023 Technical Potential for Solar Study[45] can help locate new energy infrastructure in locations to maximize benefits and minimize burdens.

As more renewable energy connects to the electric grid, we can retire the more expensive and more carbon-intensive fossil fuel power plants. Figure 6 identifies LIDAC Census tracts within three miles of a natural gas peaker plant. As the burning of fossil fuels also generates local health impacts, these communities near fossil fuel power plants stand to benefit from cleaner air as more renewable energy displaces fossil fuel electricity generation.

45 Technical Potential of Solar Study | Mass.gov

P2. Implement Building-Scale Renewables

Measure Detail

The integration of building-scale renewables on properties with ample natural resources contributes to clean energy connected to the electric grid. On-site renewable energy generation utilizes untapped space for the creation of clean energy, reducing the burden on traditional sources of electricity without large-scale development. Through identification, zoning, community coordination, funding, and infrastructure development, this measure can reduce GHG emissions from buildings.

Implementation Concepts

- **Install on-site renewable energy**: Identify suitable properties and install rooftop PV, wind, and ground/structure mount solar on commercial, residential, and industrial buildings.

GHG Reduction Estimate

Table 13: P2 GHG Reduction Estimate

Projected annual reduction in 2030:	**0.62 MMTCO_2e**
Cumulative reduction 2025 – 2030:	1.85 MMTCO_2e
Cumulative reduction 2025 – 2050: (no further adoption)	14.17 MMTCO_2e
Cumulative reduction 2025 – 2050: (continued adoption)	37.31 MMTCO_2e

Projected Reduction in 2030 GHG Inventory: 0.62 MMTCO_2e, 5.75% of Power sector emissions and <1% of total emissions compared to 2019 baseline.

This reduction measure is calculated by 1) establishing an electricity emissions baseline based on sf of residential and commercial buildings 2) calculate energy generation from NREL PVWatts tool 3) convert energy generation to emissions savings 4) calculate avoided emissions from applicable building type baseline for displacing fossil fuel electricity generation.

Calculations assume the following activity by 2030:

- 15% of single family homes install 4 kW of solar, and 5% install 4 kW wind turbine
- 10% of commercial buildings install 50 kW of solar, and 1% install a 12 kW wind turbine

Cumulative Reduction to 2050 (no further adoption): 14.17 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the measure adoption increases linearly from 0% adoption in 2025 to 15% residential solar adoption in 2030, 10% commercial solar adoption in 2030, 5% residential wind adoption in 2030, and 1% commercial wind adoption in 2030. This same 2030 adoption stays constant and does not increase annually to 2050. This measure calculates cumulative emissions reduction in 2050.

Cumulative Reduction to 2050 (continued adoption): 37.31 $MMTCO_2e$ total

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the measure adoption increases linearly from 0% adoption in 2025 to 15% residential solar adoption in 2030, 10% commercial solar adoption in 2030, 5% residential wind adoption in 2030, and 1% commercial wind adoption in 2030. This rate of adoption continues to 2050 until rates of adoption are: 75% residential solar, 50% commercial solar, 25% residential wind, 5% commercial wind. This measure calculates cumulative emissions reduction in 2050.

Impact to Low Income and Disadvantaged Communities

Expanding onsite renewables will result in decreased energy costs and local job opportunities within LIDAC communities. See the Workforce Planning Analysis section for a discussion of such benefits in greater detail. Furthermore, the addition of building scale renewables will add resilient power for critical loads and resilience hubs, while reducing air pollution from the on-site combustion of fossil fuels.

P3. Maximize Utilization of Clean Energy

Measure Detail

In addition to new clean energy generation, efficient use of all energy will result in fewer emissions, and reduced power required on the grid. Supporting the integration and efficient use of new clean energy generation requires infrastructure upgrades to the grid, including substation upgrades for renewable power integration, distribution upgrades to support increased residential electrification including vehicle charging, and reliability upgrades for buildings previously reliant on on-site fuel combustion. As we electrify our buildings, vehicles, and other processes, it is crucial that the electric grid receives appropriate upgrades to handle increased loads. Transmission, storage, and distribution upgrades to the grid can further ensure that clean energy is utilized effectively in peaks and reduce the need for existing fossil fuel generation facilities to remain online to service peak demand. Supporting the development of interconnected renewable generation and storage through microgrids can also strengthen community resilience and energy reliability.

Implementation Concepts

- **The Municipal Microgrid Initiative** will build upon previous energy resilience pilot programs and provide municipal leaders with the technical and financial assistance they need to evaluate and implement right-sized energy resilience assets for critical public facilities with a focus on supporting the most critical loads in such facilities.
  The objective for municipal microgrid projects will be to provide resilient power, with a target of 72 hours of backup per Massachusetts Emergency Management Agency's (MEMA) guidance.
- **Electric grid investments** will target inefficient operations of the grid to reduce distribution and transmission losses as compared to the 2019 5.13% losses reported via Energy Information Administration (EIA).

GHG Reduction Estimate

Table 14: P3 GHG Reduction Estimate

Projected annual reduction in 2030:	**0.28 MMTCO$_2$e**
Cumulative reduction 2025 – 2030:	0.54 MMTCO$_2$e
Cumulative reduction 2025 – 2050: (no further adoption)	0.83 MMTCO$_2$e
Cumulative reduction 2025 – 2050: (continued adoption)	11.29 MMTCO$_2$e

This reduction measure is calculated by 1) establishing an electric power emissions baseline 2) calculate emissions savings from reduction of transmission and distribution losses 3) calculate emissions savings from battery deployment during peak grid emissions periods 4) calculate avoided emissions from power sector baseline for both reduced grid losses and battery storage deployment.

Calculations assume the following activity by 2030:

- 800 kW of microgrid supported battery power deployed at dirtiest grid periods
- Updated electrical infrastructure reduces EIA's estimate of grid losses from 2019 by 50%

Projected Reduction in 2030 GHG Inventory: 0.28 $MMTCO_2e$, 2.6% of Power sector emissions and <1% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 6.33 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This measure assumes (2) 400 kW microgrids are installed in 2030, and no additional microgrids are installed. It also assumes a 50% reduction in electricity transmission and distribution losses by 2030, with no additional improvements after 2030. This measure calculates cumulative emissions reduction in 2050.

Cumulative Reduction to 2050 (continued adoption): 11.29 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This measure assumes (2) 400 kW microgrids are installed in 2030, and (2) additional microgrids are installed every 5 years through 2050 for a total of (10) 400 kW microgrids. It also assumes a 50% reduction in electricity transmission and distribution losses by 2030, with additional improvements after 2030 until there are minimal transmission and distribution losses.

Impact to Low Income and Disadvantaged Communities

Upgraded electric infrastructure will provide residents with reliable, resilient, clean energy. The Commonwealth will ensure that siting and permitting decisions consider the impact of energy projects on historically burdened communities, the voices of those who have been traditionally underrepresented in policy and decisions will be incorporated, and well-paying jobs and economic development benefits will flow to those who have traditionally not benefited from those investments. Measure implementation aims to address the major challenges of building municipal microgrids in LIDAC communities, namely high upfront costs, and technical complexity.

Natural and Working Lands

Massachusetts' natural and working lands (NWL) provide clean air and water, wildlife habitat, carbon sequestration, recreational opportunities, food and wood production, among other benefits. These ecosystems currently store at least 0.6 gigatons of carbon, equivalent to over 2 gigatons of carbon dioxide. Natural and working lands need to be protected, responsibly managed and restored as they play a significant role in the state's net GHG emissions, primarily as sinks of carbon dioxide (CO_2). As a carbon sink, there is no sublimit for the NWL sector.

Forests are the largest natural carbon sink in Massachusetts. Trees absorb CO_2 from the atmosphere during photosynthesis and store it in their biomass and in the soil. Forests cover approximately 57 percent of the state's land area, and efforts to maintain and expand forested areas can enhance carbon sequestration capacity. Priority reduction measures include, conserving, restoring, and managing these lands sustainably to ensure long-term ecosystem health, carbon sequestration and storage, and resilience to climate change and other stressors.

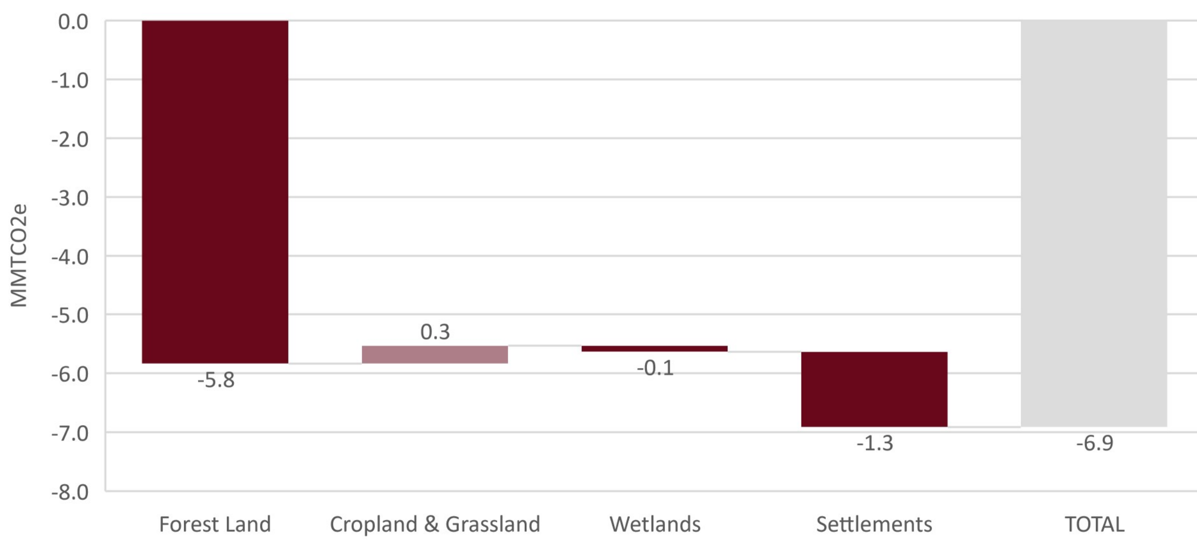


Figure 17: Natural and Working Lands Sector 2019 Emissions

N1. Implement Nature-based Solutions

Measure Detail

Massachusetts forested lands play a vital role in sequestering carbon and providing ecosystem and public health benefits. In June 2023, the Healey-Driscoll Administration launched the Forests as Climate Solutions Initiative. A key element of the Initiative is the development of climate-oriented forest management guidelines, based on the latest science, with the goals of increasing carbon storage and resilience to climate change. Healthy forests, wetlands, and natural working lands benefit the state by sequestering carbon emissions, providing health benefits, and supporting biodiversity. Though more than half of the state's land is under tree cover (57 percent of Massachusetts land is forest), only 27 percent of the state is currently permanently conserved. It is vital to advance statewide strategies to reduce the loss of natural and working lands through conservation practices, new planting, and sustainable development and infrastructure siting.

Implementation Concepts

- **Conserve Existing Forests:** Avoid new deforestation and conserve existing forests to maintain and enhance carbon sequestration and resilience.
- **Increase Restorative Planting:** Increase tree planting projects in urban and suburban areas and increase reforestation to regenerate and expand healthy forest ecosystems.

GHG Reduction Estimate

Table 15: N1 GHG Reduction Estimate

Projected annual sequestration in 2030:	**0.36 $MMTCO_2e$**
Cumulative sequestration 2025 – 2030:	1.29 $MMTCO_2e$
Cumulative sequestration 2025 – 2050: (no further adoption)	8.42 $MMTCO_2e$
Cumulative sequestration 2025 – 2050: (continued adoption)	22.48 $MMTCO_2e$

This reduction measure is calculated by 1) calculating carbon sequestration from increased tree planting 2) calculating the avoided emissions and additional carbon sequestration from baseline based on increased NWL.

Calculations assume the following activity by 2030:

- 137,742 acres of newly protected forested land.

- 16,100 acres of urban and riparian tree canopy planted. Half of this acreage is allocated for reforesting natural forest ecosystems, and half is allocated towards tree planting within urban areas. For urban, low-density, planting areas, 50 trees are assumed to be planted per acre, equating to 402,000 trees.

Projected Sequestration in 2030 GHG Inventory: 0.36 $MMTCO_2e$, an additional 5.16% of the NWL emissions sequestered in the 2019 baseline, and an additional <1% of the total emissions compared to baseline.

Cumulative Sequestration to 2050 (no further adoption): 8.42 $MMTCO_2e$

This reduction measure accounts for the additional carbon sequestration values up until the 2030 goal is met. After this goal is met, the additional 137,742 acres of protected land, the 8,050 acres of reforestation, and the 402,000 trees planted in urban areas is held constant. This reduction measure assumes the adoption percentage does not increase after 2030. The total carbon sequestered is then added for a cumulative sequestration value.

Cumulative Sequestration to 2050 (continued adoption): 22.48 $MMTCO_2e$

This reduction measure assumes a continued trajectory of implementation based on the 2050 goals listed in the CECP for forest conservation and tree planting. It is assumed that, by 2050, 564,988 acres of forest will be newly protected, and 64,400 acres of new riparian tree canopy will be planted. The new riparian tree canopy has half of its acreage allocated to reforesting natural forest ecosystems, and half of its acreage allocated to urban areas. The number of trees within urban areas equates to 1,610,000 trees with the assumption of planting 50 trees per acre. The total carbon sequestered from these measures is then added per year for a cumulative sequestration value.

Impact to Low Income and Disadvantaged Communities

Forests provide many benefits in addition to carbon sequestration and storage, including clean water and air, biodiversity-supporting habitat, local temperature regulation, recreational opportunities, and wood products. Increased tree coverage in urban communities can improve overall health and wellbeing by decreasing the urban heat island effect and emergency heat days, reducing flood risk, and improving air quality.

Land conservation, restoration, and tree planting may lead to increased property values of surrounding areas, which can exacerbate already present challenges of housing affordability and access to land ownership. Such disbenefits should be mitigated through a comprehensive approach of expanding housing access and increasing access to natural spaces for all.

Waste

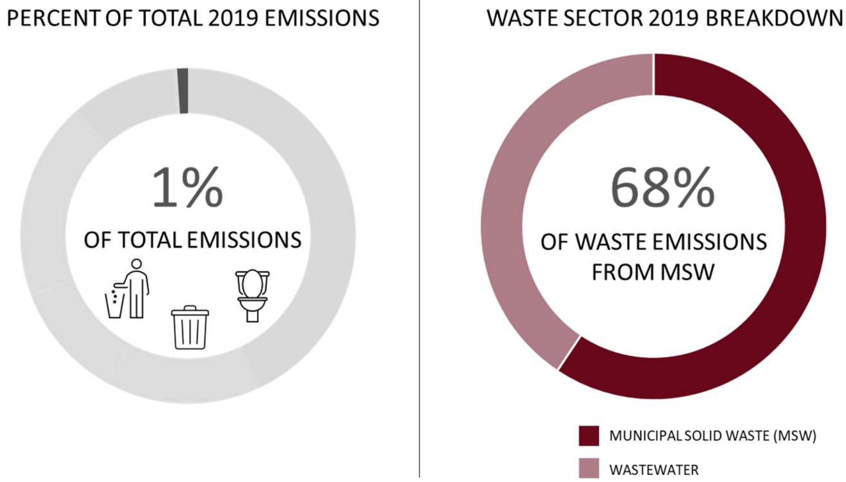


Figure 18: Waste Sector 2019 Emissions

Waste emissions include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gas (F-gas) emissions from anthropogenic activities other than those created by fossil fuel combustion including: solid waste management, including landfills, composting and anaerobic digestion, and municipal waste combustion that does not generate electricity, wastewater treatment, including septic tanks, wastewater treatment plants, and effluent management. Waste and wastewater management in Massachusetts contribute to the state's GHG inventory primarily through the treatment and release of methane and other gases from landfills and wastewater treatment facilities. Landfills are a significant source of methane (CH_4), a potent greenhouse gas with a much higher global warming potential than carbon dioxide (CO_2). When organic waste decomposes anaerobically in landfills, it generates methane as a byproduct. Priority reduction measures focus on reducing organic matter sent to landfills that can produce methane as a byproduct of decomposition.

The following table shows the 1990 historical GHG emissions and sector sub limits from the 2025/2030 and 2050 CECPs for the Waste sector, which also includes Agriculture. These values provide context for the overall GHG emissions reductions that can be expected from this sector during the periods 2025-2030 and 2025-2050.

Sector	1990	2025	2030	Difference 2025-2030	2050	Difference 2025-2050
Agriculture and Waste	3.4	1.0	0.9	-0.1	1.1	0.1

Further, municipal composting was broadly popular among many stakeholders as a measure that communities and individuals could themselves take to reduce emissions.

W1. Reduce Organic Waste through Composting

Measure Detail

Expanding composting programs and reducing food waste is a critical strategy for reducing greenhouse gases and building climate resilience. In October 2014, MassDEP banned the disposal of commercial organic waste by businesses and institutions that generate one ton or more of these materials per week. Effective November 1, 2022, the threshold was reduced to a half-ton or more weekly[46]. Diverting food wastes from disposal to composting, conversion, recycling or reuse cuts waste management costs and reduces the volume of landfill waste, an important benefit as availability of landfills in our region has become more constrained. Municipalities and partner programs can: (a) use policies and education programs to reduce consumption, divert organic waste, and encourage reuse and recycling of materials, (b) support the development of new infrastructure needed to implement composting programs, and (c) provide coordination and assistance to connect large generators of organic waste with those seeking to source those materials. Local government leadership and regional coordination is essential for Massachusetts to meet its food waste reduction goals.

Implementation Concepts

- Expand existing sites and establish new regional composting sites that can serve more customers for curbside, institutional, and municipal composting.
- Encourage municipal collaboration on composting initiatives.
- Partner with non-profits, schools, and libraries to establish food waste elimination and education programs.

GHG Reduction Estimate

Table 16: W1 GHG Reduction Estimate

Projected annual reduction in 2030:	**0.04 $MTCO_2e$**
Cumulative reduction 2025 – 2030:	0.01 $MTCO_2e$
Cumulative reduction 2025 – 2050: (no further adoption)	0.09 $MMTCO_2e$
Cumulative reduction 2025 – 2050: (continued adoption)	0.25 $MMTCO_2e$

This reduction measure is calculated by 1) establishing a food waste within municipal solid waste emissions baseline 2) calculate composting emissions from food waste 3) Sum the

[46] Commercial Food Material Disposal Ban | Mass.gov

emissions from diversion percentage of food waste to composting with the remaining food waste in landfill emissions.

Calculations assume the following activity by 2030:

- 10% of food waste is diverted from landfills into composting.

Projected Reduction in 2030 GHG Inventory: 0.04 $MMTCO_2e$, 6% of Waste sector emissions and <1% of total emissions compared to 2019 baseline.

Cumulative Reduction to 2050 (no further adoption): 0.0888 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the measure adoption does not increase after 2030. This reduction measure assumes a constant rate until the 2030 adoption threshold is met at 10% diversion of food waste into compost. 10% adoption is then held constant until 2050.

Cumulative Reduction to 2050 (continued adoption): 0.2509 $MMTCO_2e$

The 2019 baseline emissions are held constant on an annual basis until 2050. This calculation assumes the rate of adoption from 2025-2030 is constant after 2030. This reduction measure assumes a continued li trajectory of implementation based on the average annual rate of change from 2020-2030, with 10% of food waste diverted from landfills into composting in 2030.

Impact to Low Income and Disadvantaged Communities

This measure will reduce environmental and climate burdens by improving public health, especially for the communities living close to landfills by improving the soil and water quality. Decreased levels of food waste will reduce environmental burdens by decreasing methane emissions and might reduce the transportation emissions associated with trash management. Reduction of waste disposal within landfills will create economic and job benefits by providing safer working conditions for waste collection and landfill workers and economic opportunities that contribute to the workforce's development. Finally, decreased water and pollution runoff will improve community resilience to climate impacts and aid in reforestation and wetlands restoration.

Benefits Analysis

2020 Inventory for Co-Pollutants

The implementation of the measures included in this PCAP are anticipated to have a broad range of benefits. This section details the anticipated co-pollutant reductions associated with implementation of the priority measures identified in this PCAP.

Co-pollutant emissions data for Massachusetts was extracted from EPA's 2020 National Emissions Inventory to create a 2020 base county-level inventory for the sectors targeted by the priority measures included in this PCAP.[47] Table 17 presents these nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO_2), volatile organic compounds (VOC), and HAP data by county and pollutant for Massachusetts, while Table 18 presents the co-pollutants by sector and pollutant for Massachusetts. Refer to Appendix N for a full breakdown by sector, county, and pollutant.

Table 17. 2020 Massachusetts Criteria Pollutant and HAP Emissions Inventory by PCAP Sector, County, and Pollutant

Co-Pollutants by MA County					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	3,313	960	48	7,944	1,365
MA - Berkshire	1,325	1,419	33	10,407	1,466
MA - Bristol	4,364	1,806	72	12,868	1,793
MA - Dukes	737	148	8	1,259	258
MA - Essex	6,788	1,915	65	15,444	2,437
MA - Franklin	1,068	1,380	23	9,640	1,304
MA - Hampden	4,186	2,065	110	13,781	1,831
MA - Hampshire	1,204	1,282	37	9,030	1,095
MA - Middlesex	12,276	4,594	161	29,521	4,474
MA - Nantucket	378	87	2	656	165
MA - Norfolk	5,383	1,888	69	13,275	1,988
MA - Plymouth	4,028	1,676	59	13,284	1,967
MA - Suffolk	6,121	1,482	76	8,385	1,262
MA - Worcester	7,542	4,577	163	28,399	3,848
MA Total	**58,714**	**25,279**	**925**	**173,894**	**25,252**

[47] https://gaftp.epa.gov/air/nei/2020/data_summaries/2020neiMar_county_tribe_allsector.zip accessed on 2/10/2024.

Table 18. 2020 Massachusetts Criteria Pollutant and HAP Emissions Inventory by PCAP Sector, County, and Pollutant

Co-Pollutants by PCAP Sector					
PCAP Sector	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
Transportation	39,097	6,802	213	30,630	9,039
Commercial and Residential Buildings	15,732	12,833	340	44,504	7,423
Electric Power	1,352	461	123	237	55
Industry	882	1,753	6	8,646	992
Waste and Wastewater	639	3,002	224	2,228	719
Agriculture	23	357	12	385	78
Natural and Working Lands	990	71	7	87,264	6,946
MA Total	**58,714**	**25,279**	**925**	**173,894**	**25,252**

Co-pollutant Reductions

Table 19 lists anticipated changes in co-pollutants for each measure. Additional details about assumptions and methods for quantification of emissions changes are included in the appendix.

Table 19. MA Co-Pollutant Emissions Reductions Anticipated from Implementation of PCAP Priority Measures

GHG Reduction Measures	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles	-1,221	2.4	12.0	-284.5	-124.7
T2. Adopt Zero Emission Light-Duty Vehicles	-172.5	-6.8	28.9	-583.4	-172.2
T3. Increase Alternatives to Personal Vehicle Use	-1,173	-204	-6	-919	-271
B1. Increase Building Efficiency	-147.5	-29.2	-74.5	-15.7	-2.6
B2. Decarbonize Building Heating Systems	-986.7	-291.3	-14.4	-279.9	-80.9
P1. Develop New Renewable Energy Facilities	-369.2	-69.9	-146.7	-38.4	-8.9
P2. Implement Building-Scale Renewables	-108.6	-21.1	-57.4	-11.1	-2.6
P3. Maximize Utilization of Clean Energy	-1.5	- 0.3	-0.8	-0.2	-0.03
N1. Implement Nature-Based Solutions	*N/A. For GHG reduction measures associated with land use, land-use change, and forestry, co-pollutant impacts do not need to be quantified for CPRG planning grants.*				
W1. Reduce Organic Waste Through Composting	-	-	-	-84.9	-68.3

Some reduction measures co-benefits are better represented by other metrics. Table 20 lists the anticipated co-benefits for those measures. Additional details about assumptions and methods for quantification of co-benefits are included in Appendix N.

Table 20. MA Additional Co-Benefits Anticipated from Implementation of PCAP Priority Measures

GHG Reduction Measures	Additional Co-Benefits
T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles	Gallons of Gasoline Consumption avoided: 62,510,451 Gallons Gallons of Diesel Consumption avoided: 68,105,110 Gallons
T2. Adopt Zero Emission Light-Duty Vehicles	Gallons of Gasoline Consumption avoided: 210,169,819 Gallons
T3. Increase Alternatives to Personal Vehicle Use	Reductions in passenger-vehicle miles travelled: 1,017,221,924 VMT
B1. Increase Building Efficiency	Reduction in electricity demand: 5,850 GWh
B2. Decarbonize Building Heating Systems	Reduction in MA Residential Buildings sector energy use: 24,986 MWh Reduction in MA Commercial Buildings sector energy use: 30,291 MWh
P1. Develop New Renewable Energy Facilities	Renewable Energy Capacity added: 8,490 MW
P2. Implement Building-Scale Renewables	Renewable Energy Capacity added: 2,381 MW
P3. Maximize Utilization of Clean Energy	Reduction in electricity demand: 52 GWh
W1. Reduce Organic Waste Through Composting	Waste Diverted from landfills: 1,226 tons Methane emissions from landfills avoided: 1,476 MT of CH_4

Total Co-Pollutant Emissions Reductions

Table 21 compares the 2020 Baseline co-pollutants to the projected future year 2030 co-pollutant emissions reductions from PCAP scenarios.

Table 21. Co-Pollutant Emissions 2020 Baseline and PCAP Scenarios

Scenario	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (lbs.)**
2020 Baseline	58,714	25,279	925	173,894	25,252
Co-Pollutant annual reduction from PCAP Measures	-2,961	-416	-253	-1,290	-457
PCAP Scenario	55,753	24,863	672	172,603	24,795
% Reduction from Baseline	-5%	-2%	-27%	-1%	-2%

Workforce Planning Analysis

Workforce Partnerships

The clean energy transition depends upon Massachusetts continuing to develop a diverse, inclusive workforce and to support high-quality jobs. For Massachusetts to meet its decarbonization goals, rapid workforce expansion will need to occur across all segments of the clean energy economy. However, 88 percent of Massachusetts Clean Energy employers are already struggling to source talent due to existing labor shortages and skills gaps.[48] To better understand these challenges and opportunities, Massachusetts conducted an analysis to quantify clean energy jobs at the regional, sector, and occupational levels, including climate-critical occupations associated with the CPRG priority measures.

Powering the Future: A Massachusetts Clean Energy Workforce Needs Assessment found that by 2030, the Massachusetts clean energy workforce will need to grow by more than 36 percent, requiring 38,000 more workers to be trained and ready to deploy some or all their time on climate-critical work.[37] Additionally, Massachusetts recognizes the tremendous economic impact of the Biden-Harris administration's historic federal investments in clean energy and climate, which, according to information shared by the White House in August of 2023, have created more than 170,000 jobs and are projected to create more than 1.5 million additional jobs over the next decade.[49] The priority measures detailed in this plan directly support the state's decarbonization goals surrounding Clean and High-Performance Buildings, Clean Power and Net Zero Grid, Clean Transportation. Across these major clean energy sectors, the occupations that are projected to see the highest demand and are at the greatest risk of facing supply bottlenecks between now and 2030 include HVAC technicians, electricians, line workers, construction laborers, and energy auditors.

Workforce Development Strategies

To address these projected workforce supply gaps and support the expansion of a robust and diverse clean energy workforce, the Commonwealth is pursuing four major workforce development strategies, which have been detailed in The *Massachusetts Clean Energy and Climate Plan for 2050* and the *Recommendations of the Climate Chief* report.[50,51] These four strategies will not only directly support implementing the priority measures included in the PCAP but also contribute to the expansion of high-quality jobs and increased access for traditionally underserved populations.

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[48] Powering the Future: A Massachusetts Clean Energy Workforce Needs Assessment, https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

[49] https://www.whitehouse.gov/briefing-room/statements-releases/2023/08/16/fact-sheet-one-year-in-president-bidens-inflation-reduction-act-is-driving-historic-climate-action-and-investing-in-america-to-create-good-paying-jobs-and-reduce-costs/#:~:text=Investments%20in%20clean%20energy%20and,to%20estimates%20by%20outside%20groups.

[50] https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050

[51] https://www.mass.gov/files/documents/2023/10/24/CLIMATE%20REPORT.pdf

First, the Commonwealth is committed to providing ongoing climate-critical occupational training, including support for minority and women-owned small business enterprises (MWBEs), through the annual Equity Workforce Development Programming administered by the Massachusetts Clean Energy Center (MassCEC). In FY23 alone, MassCEC awarded over $18 million in Equity Workforce grants, which provided funding to train workers in low income and disadvantaged communities for high-quality careers and expanded the state's capacity to address training gaps in priority occupations. For example, the Equity Workforce Program provided Greenfield Community College with the funds to develop and launch an HVAC training program with focused instruction for heat pump installation and maintenance. The Healey-Driscoll administration recently announced additional funding to support expanded HVAC technician and heat pump training throughout the state's community college system.[52]

Second, Massachusetts is leveraging cross-agency coordination through the Workforce Skills Cabinet[53] and with leadership from Massachusetts Clean Energy Center to establish clean energy as a statewide priority industry sector, with increased integration across education and workforce programming. For example, the Executive Office of Education (EOE), in partnership with EEA and MassCEC, launched a new Clean Energy Innovation Pathway program to increase early awareness of clean energy occupations. Efforts to define and launch a statewide Climate Service Corps will provide expanded opportunities for youth and young adults from environmental justice communities to access clean energy and climate pathways. Additionally, ongoing coordination with the Executive Office of Labor and Workforce Development (EOLWD) is advancing opportunities to blend and braid state-funded workforce initiatives like the Career Technical Initiative, which expands adult access to vocational school training programs, with MassCEC's clean energy workforce development funding, which can provide augmented recruitment, wrap-around support services, and paid work-based learning offerings.

Third, Massachusetts is working to increase coordination with labor unions to assist in climate-critical training and retraining, especially for those transitioning from other sectors and/or fossil fuel-based roles. MassCEC awarded the International Brotherhood of Electrical Workers 103 and the National Electrical Contractors Association a grant to refurbish their training center's wind turbine to integrate hands-on training into their offerings and a planning grant to expand their efforts to help a more diverse range of electricians and electrical contractors access opportunities in the clean energy industry. The Office of Climate Innovation and Resilience hosts a regular coordination call with leaders from Climate-Critical Unions to ensure that federal funding opportunities are also optimized to support job quality. This increased coordination helped inform the strategies in this plan, and, among other outcomes, it also led to Massachusetts developing a plan to prioritize job quality through high-road worker-centered workforce training models, which was highlighted in the state's recent submission to the Solar For All funding opportunity.

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[52] https://www.wbur.org/news/2024/01/17/2024-massachusetts-state-of-the-commonwealth-address-maura-healey (swap reference for mass.gov

[53] https://www.mass.gov/orgs/workforce-skills-cabinet

Finally, Massachusetts recognizes that to meet our state's climate goals and successfully implement the priority measures in this plan, the above strategies need to be expanded and honed through the development and implementation of a comprehensive, cross-agency plan for clean energy and climate resilience workforce development. As the state wraps up the development of a new four-year workforce development plan to be submitted to the U.S. Department of Labor through the requirements of the Workforce Innovation Opportunity Act (WIOA), MassCEC and the Workforce Skills Cabinet are launching a more targeted effort to develop a comprehensive workforce development plan for clean energy and climate resilience. Through this process, the state will identify additional recommendations and programmatic needs and look to optimize state investment alongside federal funding like the DOE Training for Residential Energy Contractors programs. To ensure these efforts lead to expanded job quality and increased access, Massachusetts will utilize current stakeholder engagement mechanisms like Climate Office's Climate Critical Labor coordination meeting, EEA's Justice 40 and Equitable Investment Working Group, and MassCEC's Equity Workforce Working Group to increase input and collaboration. Finally, to track progress and address challenges, Massachusetts will develop a more comprehensive approach to measuring clean energy workforce development outcomes across programs.

Workforce Analysis by Sector

Job growth is projected across all clean energy technology sectors, four key focus areas combined encompass about 87 percent of all clean energy jobs in the state for both 2022 and 2030. These areas are: High-Performance Buildings,[54] Offshore Wind, Clean Transportation[55] and Net Zero Grid.[56] Employment in High-Performance Buildings is roughly five times greater than all three other focus areas combined in 2022 and will see the largest absolute number of jobs added. Offshore Wind has the largest projected growth rate (724%), followed by Clean Transportation (111%) and Net Zero Grid (70%), as compared to High-Performance Buildings (17%).

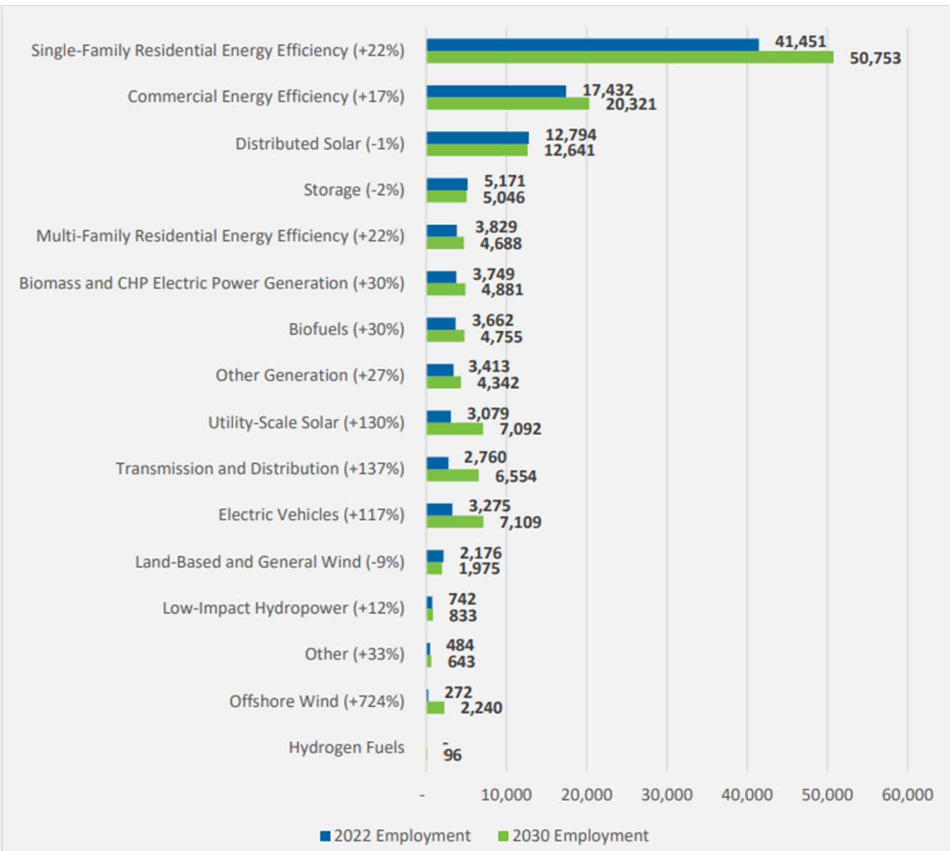

Figure 19: Clean Energy Employment by Sub-sector 2022-2030[57]

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[54] The High-Performance Buildings focus area includes all energy efficiency sub-technologies as well as distributed solar.

[55] The Alternative Transportation focus area does not include “Other” vehicles as counted in the Massachusetts Clean Energy Industry Report.

[56] The Net-Zero Grid Focus Area contains transmission and distribution, energy storage and utility-scale solar.

[57] In August 2022, An Act Driving Clean Energy and Offshore Wind removed woody biomass as an eligible fuel as part of the Massachusetts Clean Energy and Renewable Energy Portfolio Standards. While still eligible for the Alternative Portfolio Standard, this law brings into question whether jobs associated with woody biomass should be considered clean energy jobs. While woody biomass, biofuels, and biomass electric power generation fall outside of MassCEC’s four Focus Areas and

High Performance Buildings

Workers in this focus area construct new and retrofit existing homes and businesses with energy-efficient fixtures and appliances and improved insulation and air sealing.[58] The scale of work needed to retrofit existing residential and commercial properties will require a significant number of workers. Given the current tightness of the labor market as well as the federal 2021 Infrastructure Investment and Jobs Act — which will likely divert worker resources to other projects throughout the state — the demand for construction-related workers will likely accelerate. The scale of workers needed means that awareness and career-entry initiatives are paramount to ensure an adequate number of workers to complete retrofit activities and the construction of new high-efficiency buildings.

With nearly 13,000 additional workers needed by 2030, demand will be high across many occupations, particularly those involved in building new energy efficient buildings and retrofits, including Construction Laborers, Insulation Workers, and Building Inspectors, since energy efficiency will be the core focus of the state's building decarbonization efforts. Additionally, 430 HVAC-R Mechanics and Installers and 330 Electricians will be needed for High-Performance Buildings activities. While this is a significant number, demand for these professions is expected to continue to increase in the following decades as the pace of electrification of buildings accelerates beyond 2030.

Table 22: High-Growth Occupations in the High-Performance Buildings Focus Area

High-Growth Occupations in the High-Performance Buildings Focus Area	
Construction Laborers	(+1,420 additional workers by 2030) will construct new energy-efficient buildings and participate in construction duties in more extensive retrofits.
Insulation Workers	(+970) will spray and install additional insulation.
General Operations Managers	(+600) will manage construction and retrofit activities.
Construction and Building Inspectors (including HERS Raters and Energy Auditors)	(+530) is an occupation where some workers will work for private companies to evaluate the energy efficiency of homes while other workers will ensure buildings meet relevant building code standards.
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	(+430) will install and repair high efficiency HVAC-R systems (including heat pumps) and other energy-efficient technologies.

associated programming, MassCEC is maintaining these jobs within the Workforce Needs Assessment to maintain alignment with the 2025 & 2030 CECP, which includes these jobs within the broader analysis, for purposes of cross-comparison.

[58] Under the 2025 & 2030 CECP 'phased' scenario, decarbonization efforts between 2022 and 2030 will focus heavily on insulation, air sealing and enhancing building envelopes, allowing for a ramp-up process with deeper electrification efforts occurring after 2030.

Net-Zero Grid

The electrification of much of the Massachusetts economy will require efforts to upgrade and expand the grid and make it more resilient. Net Zero Grid-related jobs are likely to be found throughout the state. Much of this work will include bolstering transmission and distribution lines and installing utility-scale solar and energy storage, and many of the occupations projected to see the greatest demand require extensive electrical safety training. The duration of these trainings means that ramping up the capacity for these programs is essential long before full demand is needed. This creates a balancing act that will require cooperation between interested parties, including utilities, utility-scale project developers, unions, and regulators. If these parties work together to produce forward-looking forecasts that they are confident in, they can be sure to have the appropriately skilled and certified talent as it is needed.

Table 23: High-Growth Occupations in the Net Zero Grid Focus Area

High-Growth Occupations in the Net Zero Grid Focus Area	
Electricians	(+1,440 additional workers by 2030) will conduct an array of work, from wiring substations to connecting utility scale solar to the grid.
Solar Photovoltaic Installers	(+800) will install utility scale solar panels and connect them to the grid. These workers are required to be licensed Electricians in the state of Massachusetts, further straining the Electrician training network.[1]
Line Installers and Repairers	(+600) install and replace transmission and distribution lines.
Construction Laborers	(+550) will assist in the construction of infrastructure that supports solar generation sites and installation of transmission and distribution lines.

Clean Transportation

The electrification of transportation will also require substantial electrical expertise. Much of the employment growth within Clean Transportation is among Electricians, who are needed to install commercial and residential charging stations throughout the state. The licensing process for Electricians takes time, so if the demand for charging infrastructure spikes suddenly — an outcome that is likely if EV adoption follows trends observed elsewhere — the supply of Electricians will not be able to keep pace. Publicly funded charging stations grants could offer an avenue to increased collaboration and data sharing, resulting in opportunities for project labor agreements, aligned workforce development funding and clearer metrics about the anticipated the number of workers required according to the duration and scale of the projects — all of which could support stronger alignment of workforce supply.

Beyond a strong demand for Electricians, there will also be increased need for professionals who understand the logistics and operations of electric fleets. Clean Transportation jobs are likely to be available throughout the state, though logistics-related opportunities will tend to cluster near transportation hubs.

Table 24: High-Growth Occupations in the Clean Transportation Focus Area

High-Growth Occupations in the Clean Transportation Focus Area	
Electricians	(+2,100 additional workers by 2030) will install EV charging infrastructure.
Automotive Technicians and Repairers	(+240) will be responsible for maintaining private and commercial EVs.
General and Operations Managers	(+210) will oversee the buildout of charging infrastructure.
Logisticians and Project Manager Specialists	(+80) will manage electric fleets to ensure maximum operational capacity.
Electric Power-Line Installers and Repairers	(+70) will support the installation of additional distribution as necessary.
Construction Laborers	(+60) will build necessary structures for EV charging

New Renewable Generation: Offshore Wind & Solar Energy

Offshore Wind (OSW) is a nascent industry in Massachusetts and the United States, but many of the roles that will see the largest increase in demand are construction and manufacturing roles that will assemble components and install turbines and supporting infrastructure. A recent report by Vineyard Wind, the company responsible for constructing the nation's first commercial-scale OSW project, highlights the number and types of jobs created and sustained through the development and construction phases of the Vineyard Wind project.[59]

While some of the high-growth OSW occupations, such as Electricians, have existing shortages of workers, other occupations, such as Miscellaneous Assemblers and Fabricators and Laborers and Material Movers, are in surplus in the overall economy. Demand within OSW represents an opportunity for these workers to transition into with some training and Global Wind Organization[60] certification. Inspectors, Testers, Sorters, Samplers, and Weighers are also projected to decline throughout the overall state economy and could likely transition to OSW activities with little additional training.

Table 25: High-Growth Occupations in the Offshore Wind Focus Area

High-Growth Occupations in the Offshore Wind Focus Area	
Electricians	(+120 additional workers by 2030) will work on a range of activities, including connecting turbines to transmission cables.
Miscellaneous Assemblers and Fabricators	(+120) will assemble parts of turbines.
Structural Metal Fabricators and Fitters	(+100) will assemble larger structural pieces of turbines and jackets.
Miscellaneous Metal and Plastic Workers	(+80) will be involved in the manufacturing of turbine components.
Miscellaneous Installation, Maintenance, and Repair Workers	(+110) will ensure facilities and machinery are operational. Some of these roles may include maintenance on or around turbines, which may require completion of several Global Wind Organization (GWO) courses.

While solar is an established industry in Massachusetts, particularly utility scale solar has a projected growth rate of +130 percent by 2030. This includes a need for an additional 730 Solar

[59] "Vineyard Wind 1 Impact on Jobs and Economic Output," November 2022, Prepared by UMass Dartmouth, https://static1.squarespace.com/static/5a2eae32be42d64ed467f9d1/t/63ed4fea5d36ec3e4dcef2f3/1676496874921/VW1+2022+Jobs+Report.pdf.

[60] Global Wind Organization (GWO) training is required for most workers who will be on or near the water.

Photovoltaic Installers by 2030. While Solar Photovoltaic Installers are a different occupation from Electricians, they are required to have electrician licenses in Massachusetts, making the total number of additional workers with Electrician licenses in excess of 6,000, or a 32 percent increase in Electrician licenses. Additional roles that will see growth to expand utility scale solar generation in Massachusetts include construction laborers and electric power line installers.

Table 26: High-Growth Occupations in Utility Scale Solar

High-Growth Occupations in Utility Scale Solar	
Electricians	(+1090 additional workers by 2030) will work on installing and connecting solar photovoltaic panels.
Construction Laborers	(+260) will support a range of roles, including the bracketing and piling for utility scale solar development.
Electric Power Line Installers	(+120) will support the installation of additional distribution capacity as necessary.

Conclusion

Massachusetts' Priority Climate Action Plan highlights the need for climate related funding with near term, implementation ready, emissions reduction actions that will benefit the communities most in need. Funding for the measures listed within this document will align with ongoing efforts within the state to achieve the goals outlined in the Massachusetts Clean Energy and Climate Plan while deepening community engagement, creating momentum through addressing pivotal climate challenges within the state. The targets within this plan depict only a partial list of the climate needs in the state of Massachusetts and is not an exhaustive list of all the ongoing strategies within the state.

Following the release of this Priority Climate Action Plan, Massachusetts will publish a Comprehensive Climate Action Plan that will further build off the ideas presented in the PCAP. Along with the funding from the CPRG, the Office of Climate Innovation and Resilience will continue to engage with the community and invest in sustainable practices throughout the commonwealth by partnering with state and federal organizations and funding sources.

Appendix A – LIDAC Census Tracks

Municipality	County	Census Tracts
Adams	Berkshire County	9221
Amherst	Hampshire County	8204
Attleboro	Bristol County	6314
Barnstable	Barnstable County	125.02, 153
Boston	Suffolk County	2.02, 8.02, 104.5, 402, 408.1, 501.01, 502, 503, 504, 505, 506, 507, 509.01, 510, 511.01, 607, 610, 611.01, 701.01, 702, 704.02, 705, 709, 711.01, 712.01, 801, 803, 804.01, 805, 806.01, 808.01, 810.01, 812, 813, 815, 817, 819, 820, 821, 901, 902, 903, 904, 906, 907, 909.01, 910.01, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921.01, 924, 1001, 1002, 1003, 1004, 1005, 1010.01, 1010.02, 1011.01, 1011.02, 1102.01, 1104.01, 1304.06, 1401.02, 1401.06, 1403, 2060, 9801.01, 9803, 9811
Brockton	Plymouth County	5103, 5104, 5105.02, 5105.03, 5108, 5109, 5110, 5112, 5114, 5115
Cambridge	Middlesex County	3522, 3527
Chelsea	Suffolk County	1601.01, 1602, 1603, 1604, 1605.01, 1605.02, 1606.01, 1606.02
Chicopee	Hampden County	8106.01, 8108, 8109.01, 8111.01, 8111.02
Dudley	Worcester County	7542, 7543

Everett	Middlesex County	3421.01, 3421.02, 3422.01, 3423, 3424, 3425, 3426
Fall River	Bristol County	6401, 6402, 6403, 6404, 6405, 6406, 6407, 6408, 6409.01, 6410, 6411.01, 6412, 6413, 6414, 6415, 6416, 6419, 6420, 6422
Falmouth	Barnstable County	148
Fitchburg	Worcester County	7105, 7107, 7108, 7110
Framingham	Middlesex County	3831.01, 3831.02, 3832, 3834, 3835.01
Gardner	Worcester County	7071, 7072
Gloucester	Essex County	2214, 2215, 2216
Greenfield	Franklin County	413, 414
Haverhill	Essex County	2601, 2602, 2608, 2609
Holyoke	Hampden County	8114, 8115, 8116, 8117, 8118, 8120.01, 8120.02, 8121.03
Lawrence	Essex County	2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517
Lenox	Berkshire County	9241
Leominster	Worcester County	7092.02, 7094, 7096
Lowell	Middlesex County	3101, 3104, 3105, 3107, 3111, 3112, 3113, 3117, 3118, 3119, 3120, 3121, 3122, 3124, 3883
Ludlow	Hampden County	8104.03
Lynn	Essex County	818, 2052, 2055, 2056, 2058, 2061, 2062, 2063, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072
Malden	Middlesex County	3412, 3413, 3414, 3415, 3418
Marlborough	Middlesex County	3213
Methuen	Essex County	2524

Milford	Worcester County	7443, 7444
Montague	Worcester County	7320.01
New Bedford	Bristol County	6501.02, 6504, 6505, 6506, 6507, 6508, 6509, 6511, 6512, 6513, 6514, 6516, 6517, 6518, 6519, 6520, 6523, 6524, 6525, 6526, 6527
North Adams	Berkshire County	9214, 9215, 9353
North Attleborough	Bristol County	6301.01
Pittsfield	Berkshire County	9001, 9002, 9004, 9006
Quincy	Norfolk County	4172, 4175.01, 4175.02, 4176.01, 4178.02, 4180.04
Revere	Suffolk County	1701, 1702, 1704, 1706.01, 1707.01, 1707.02, 1708
Salem	Essex County	2043, 2108
Somerville	Middlesex County	3501.04, 3514.03, 3515
Southbridge	Worcester County	7571, 7572, 7573
Springfield	Hampden County	8001.01, 8001.02, 8002.01, 8002.02, 8004, 8005, 8006, 8007, 8008, 8009, 8011.01, 8011.02, 8012, 8013, 8014.01, 8014.02, 8015.01, 8015.02, 8015.03, 8016.05, 8017, 8018, 8019.01, 8019.02, 8020, 8022, 8023, 8026.01
Stoughton	Norfolk County	4561.02, 4563.01
Taunton	Bristol County	6136, 6138, 6140
Ware	Hampshire County	8201.02
West Springfield	Hampden County	8122.01, 8123
Worcester	Worcester County	407.01, 7304.01, 7305, 7311.01, 7312.03, 7312.04, 7313, 7314, 7315, 7316, 7317, 7318, 7319, 7322.01, 7322.03, 7323.02, 7324, 7325, 7326, 7327, 7330

Appendix B – GHG Emission Inventory Details

The Massachusetts GHG Inventory has been prepared by MassDEP and is posted online at https://www.mass.gov/doc/appendix-c-massachusetts-annual-greenhouse-gas-emissions-inventory-1990-2020-with-partial-2021-2022-data/download. The Massachusetts GHG emissions inventory includes anthropogenic emission estimates for primary GHGs (i.e., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3) for the full geographic coverage of the state. Emissions are reported in CO_2 equivalent units. Direct (e.g., power generation) emissions and emissions from power imported to Massachusetts are included in the inventory, reflecting emission from total state electricity use.

The inventory methods, data sources and approach by sector are summarized below. The lists in the following documents a. through d. on which the inventory methodology description details for that sector can be found. The last column of the table lists the spreadsheet e. tab(s) on which calculations or values can be found:

a) *Statewide Greenhouse Gas Emissions Level: 1990 Baseline Update* May 2021 at https://www.mass.gov/doc/statewide-greenhouse-gas-emissions-level-proposed-1990-baseline-update-including-appendices-a-b-may-2021/download
b) *Addendum to the Statewide Greenhouse Gas Emissions Level: 1990 Baseline Update* February 2022 at https://www.mass.gov/doc/addendum-to-statewide-ghg-level-proposed-1990-baseline-update-february-2022/download
c) *2nd Addendum to the Statewide Greenhouse Gas Emissions Level: 1990 Baseline Update* June 2022 at https://www.mass.gov/doc/2nd-addendum-to-statewide-ghg-level-proposed-1990-baseline-update-june-2022/download
d) *Response to Comments on the Statewide Greenhouse Gas Emissions Level: 1990 Baseline Update, and Addendum and 2nd Addendum to the Update* December 2022 at https://www.mass.gov/doc/response-to-comments-on-the-statewide-greenhouse-gas-emissions-level-1990-baseline-update-and-addendum-and-2nd-addendum-to-the-update-december-2022/download
e) *Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990–2020, with Partial 2021 & 2022 Data* spreadsheet at https://www.mass.gov/doc/appendix-c-massachusetts-annual-greenhouse-gas-emissions-inventory-1990-2020-with-partial-2021-2022-data/download
f) Note, as discussed in the above documents, pursuant to Massachusetts state law, MassDEP's GHG inventory estimates electric sector emissions that occur outside the borders of Massachusetts, because less than half the electricity Massachusetts uses is generated in-state. The spreadsheets calculating these "import" emissions for each calendar year are at https://www.mass.gov/lists/massdep-emissions-inventories.

Sector	Document a	Document b	Document c	Document d	Document e tab*
Transportation	10, 13, 16-17	2 - 4		4, 7-8	CO2FFC, Mobile & Biogenic Combustion
Electricity in-state	10, 16-17			4, 9	CO2FFC, Stationary, Solid Waste & Biogenic Combustion
Electricity imports	12-13, 15			9	Elec Import, EIA Adjust & Appendices D through W (item f in the list above)
Residential	10, 13, 16-17			4, 7-8	CO2FFC, Stationary & Biogenic Combustion
Commercial	10, 13-14, 16-17			4	CO2FFC, Stationary & Biogenic Combustion
Industrial (fuel combustion)	10, 13, 16-17			4	CO2FFC, Stationary, Solid Waste & Biogenic Combustion
Natural Gas Systems – Distribution & Post-Meter	10, 11-12, 15		3	4-7	NG Sum & Distribution & Post-Meter
Natural Gas Systems – Transmission & Storage	10, 14-15			4-7	NG Transmission& Storage
Waste	10, 16-17			4-6	Solid Waste
Wastewater	10, 14			4-6	Wastewater & Biogenic Combustion
Industrial Processes	10				Indust. Proc.
Agriculture	10				Agriculture
NWL				8-9	NWL

Massachusetts intends to compare forward-looking GHG reduction analyses to the 2019 year of the Inventory (noting that 2020 was an anomalous year with the global COVID pandemic). A full breakdown of the emissions by sector is provided in the following table:

2019 GHG Emissions (million metric tons of carbon dioxide equivalent, MMTCO2e) as of March 2023

Sector	**2019 MMTCO2e**
Transportation CO_2e from Fuel Combustion	**30.81**
Transportation - CO_2	30.44
Transportation - CH_4 & N_2O	0.38
Electricity Total CO_2e from Fuel Combustion	**10.72**
Electric Generation - CO_2	6.22
Electric Generation - CH_4 & N_2O	0.01
Electric Generation - MSW (CO_2, CH_4 & N_2O)	1.09
Electricity Imports (CO_2, CH_4 & N_2O)	3.40
Residential CO_2e from Fuel Combustion	**13.74**
Residential - CO_2	13.60
Residential - CH_4 & N_2O	0.14
Commercial CO_2e from Fuel Combustion	**8.07**
Commercial - CO_2	8.02
Commercial - CH_4 & N_2O	0.04
Commercial CO_2 from Fossil Fuel Use by Fuel Cells	0.01
Industrial CO_2e from Fuel Combustion	**3.40**
Industrial - CO_2	3.23
Industrial - CH_4 & N_2O	0.01
Industrial - MSW (CO_2, CH_4 & N_2O)	0.02
Industrial - Nat Gas System (CO_2, CH_4 & N_2O)	0.14
Industrial Processes CO_2e	**3.26**
Lime, Dolomite, Soda Ash, Urea (CO_2)	0.17
ODS Substitutes, Semiconductor Manufacturing, Electricity Transmission (HFCs, PFCs, NF_3, SF_6)	3.00
Natural Gas Transmission and Storage System	0.08
Agriculture CO_2, CH_4 & N_2O)	**0.27**
Waste	**0.75**
Wastewater (CH_4 & N_2O)	0.44
Municipal Solid Waste - Landfills Only (CO_2, CH_4 & N_2O)	0.30
Natural and Working Lands (NWL)	**-6.91**
Forest Land	-5.84
Cropland & Grassland	0.31
Wetlands	-0.11
Settlements	-1.27
Gross Emissions *(excluding NWL)*	**71.67**

Note: Due to rounding, some totals appear higher or lower than the simple sum of the sectors. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

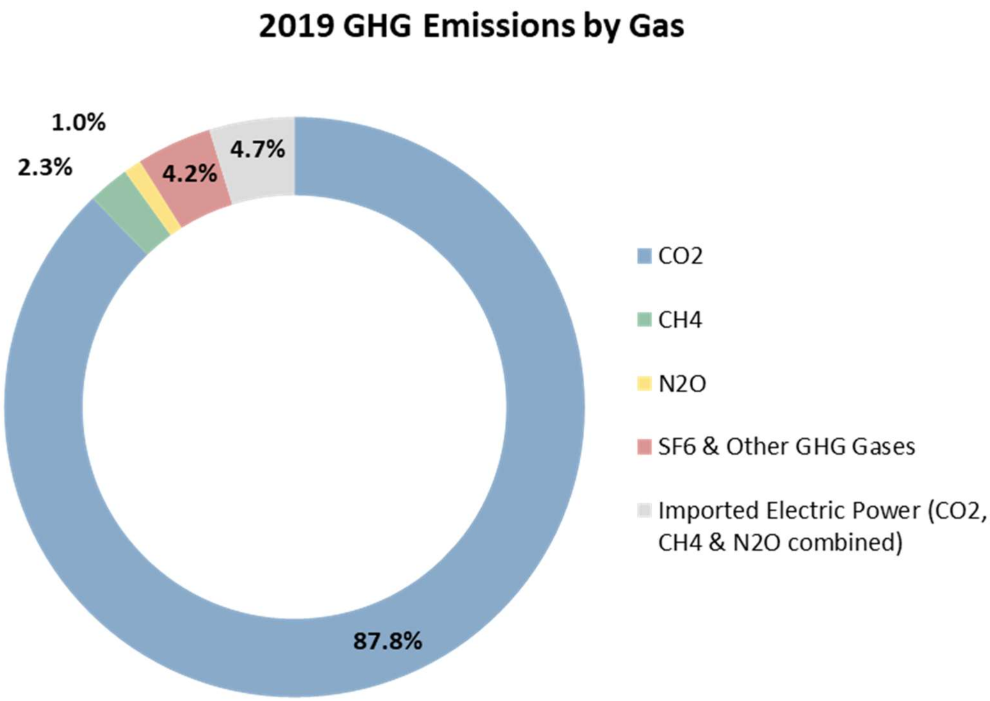

Figure 20: 2019 GHG Emissions by Gas

Electric Grid Emissions

The standard MA electricity emissions factor, 412 lbsCO2e/MWh, accounts for in-state generation and CO2e emissions from electricity imported into MA in pounds (lbs.) and million metric tons of CO_2e ($MMTCO_2e$), including emissions from GIS certificates. The rate is calculated from 23,877,232,466 lbs. of CO_2e MA Total Emissions from Electricity Consumption including emissions from MA net GIS certificates, and 57,936,811 MWh for MA Electric Load Including MA behind-the-meter GIS certificates and Pumping.

Appendix C – T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles

Funding Intersections

- BIL programs including but not limited to the DOT National Electric Vehicle Infrastructure Program (DOT NEVI)
- IRA credits including but not limited to the Clean Heavy-Duty Vehicle Program
- The Federal Transit Administration
- MassCEC programs
- Incentives from the Massachusetts DEP
- Rebates from the Massachusetts DOER
- The Federal Transit Administration
- IRA credits including but not limited to the Clean Heavy-Duty Vehicle Program

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including but not limited to the Massachusetts DOER, MassCEC, MassDEP, Massachusetts DPU, Massachusetts EEA, MassDOT, DCAMM
- Tribal Nations

Implementation Schedule and Milestones

Implementation will depend on the funding available. Funding from sources such as the Clean Heavy-Duty Vehicle Program and the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Trucks and MOR-EV Medium-/Heavy-Duty Rebate Programs determine the rate at which the Commonwealth can implement medium and heavy-duty vehicle electrification projects.

Massachusetts is pursuing the major milestones of reducing transportation emissions 18% by 2025 and 34% by 2030 from 1990 levels. Modeling form the CECP projects a target of 26,000 MD/HD vehicles by 2030, or 10% of the MD/HD fleet.

Expected Geographic Location

Statewide with a focus on LIDAC communities, especially but not limited to, those communities most impacted by high traffic corridors.

Milestones for Obtaining Legislative or Regulatory as Appropriate

Medium-duty and heavy-duty trucks, vans, buses, and other vehicle types: Authority to implement incentive programs, enable vehicle procurement for state and municipal fleets, deploy electric vehicle charging infrastructure, and set increasing sale requirements exists in statute.

Statutory authority for the Department of Energy Resources to administer a zero-emission vehicle incentive program, including light-, medium and heavy-duty vehicles, is provided in MGL.c.25A § 19. The Department of Energy Resources currently administers the MOR-EV Program to fulfill this authority, with program regulations codified in 225 CMR 26.00.

State procurement of electric vehicles is conducted under MGL c. 30, § 51 and by Executive Order 594. Municipal authority to procure vehicles is governed by c.30B.

Authority for public electric charging infrastructure is based in c.25A § 16. State procurement of electric vehicles is conducted under MGL c. 30, § 51 and by Executive Order 594. Municipal authority to procure vehicles is governed by MGL c.30B.

Massachusetts has adopted the California Advanced Clean Trucks requirements requiring manufacturers to meet California's Zero Emission Vehicle (ZEV) production and sales requirements. Beginning with model year 2025, manufacturers will be required to sell zero-emission trucks as an increasing percentage of their annual sales for Class 2b through Class 8 vehicles.

Heavy-duty Transit Buses: The Department of Energy Resources currently administers the MOR-EV Program for light-, medium- and heavy-duty vehicles Statutory authority for the Department of Energy Resources to administer an electric vehicle incentive program, including light-duty vehicles, is provided in MGL.c.25A § 19 with program regulations in 225 CMR 26.00. State procurement of electric vehicles is conducted under MGL c. 30, § 51 and by Executive Order 594. Municipal authority to procure vehicles is governed by c.30B.

Metrics for Tracking Progress

Metrics for tracking progress are ways that the state can ensure improvements are being made towards milestones and goals. Such metrics can include:

- Number and percent of medium- and heavy-duty vehicle registrations in Massachusetts that are electric vehicles
- Number of installed electric vehicle charging ports
- Vehicle miles traveled (VMT) for medium- and heavy-duty vehicles or vehicle miles traveled by mode
- Number of fleets with EV's
- Number of electric school buses and percent of school buses that are electric
- Number of electric transit buses and percent of transit buses that are electric
- Additional infrastructure to support electric vehicles (electric bus garages)
- Air quality measurements along major highways and interstates

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GHG Reduction Methodology

1. Use Massachusetts Vehicle Census MassVehicleCensus | GeoDOT (arcgis.com) for fossil fuel medium- and heavy-duty vehicle counts, and daily VMT from 1/1/2020.
    a. Medium-Duty: 105,534 vehicles, 3,881,697 daily VMT
    b. Heavy-Duty: 53,467 vehicles, 2,054,441 daily VMT
2. Gasoline / diesel fuel split provided by MassDOT with 56.3% of medium-duty vehicles diesel; 43.7% of medium-duty vehicles gas; 98.9% of heavy-duty vehicles diesel; and 1.1% of heavy-duty vehicles gas
3. Use California Air Resources Board, 2020. Advanced Clean Fleets - Cost Workgroup Cost Data and Methodology Discussion Draft for average mpg assumptions.
    a. Medium-duty diesel vehicles: 13.8 mpg (taken from class 4-5)
    b. Medium-duty gas vehicles: 10.9 mpg (taken from class 4-5)
    c. Heavy-duty diesel vehicles: 8.65 mpg (average between class 6-7 mpg and class 8 mpg)
    d. Heavy-duty gas vehicles: 5.29 mpg (average between class 6-7 mpg and class 8 mpg)
4. Calculate annual gallons of fuel using average mpg and annual VMT values

$$\frac{Annual\ VMT}{average\ mpg} = Annual\ gallons\ of\ fuel$$

5. Calculate baseline emissions
    a. Use 2020 EPA GHG Emission Factors Hub for kg CO2/gallon, g CH4/mile, g N2O/mile
    b. For CO2, use:
        i. 10.21 kg CO2/gallon diesel fuel factor
        ii. 8.78 kg CO2/gallon gasoline fuel factor
    c. For CH4, N2O, assume diesel medium and heavy-duty vehicles in vehicle year range: (2007-2018):
        i. 0.0095 g CH4/mile, 0.0431 g N2O/mile diesel factors (2010)
        ii. 0.0320 g CH4/mile, 0.0015 g N2O/mile gasoline factors (2007-2018)
6. Calculate CO2e using factors in 2020 EPA GHG Emission Factors Hub
    a. 1 kg CO2 = 1 kg CO2e
    b. 1 kg CH4 = 25 kg CO2e
    c. 1 kg N2O = 298 kg CO2e
7. Assume 10% of medium- and heavy-duty vehicles electrify
8. Calculate electricity use from converted electric vehicles
    a. Use California Air Resources Board, 2018 Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles
    b. Medium duty: 0.7 kWh/mile
    c. Heavy duty: 2.1 kWh/mile

$$Electricity\ used\ by\ EVs = \ 10\% * Total\ Annual\ VMT * \left(\frac{kWh}{mile}\right)$$

9. Use grid emissions factor (412 $lbCO_2e/MWh$) to calculate emissions associated with electric vehicles
10. Calculate greenhouse gas emissions from remaining gallons of fuel
    a. 90% of gallons of fuel, 90% of VMT
    b. Use [2020 EPA GHG Emission Factors Hub] for kg CO_2/gallon, g CH_4/mile, g N_2O/mile
    c. For CO_2, use diesel fuel factor:
        i. 10.21 kg CO_2/gallon diesel fuel factor
        ii. 8.78 kg CO_2/gallon gasoline fuel factor
    d. For CH_4, N_2O, assume medium and heavy-duty vehicles in vehicle year range:
        i. 0.0095 g CH_4/mile, 0.0431 g N_2O/mile diesel factors (2010)
        ii. 0.0320 g CH_4/mile, 0.0015 g N_2O/mile gasoline factors (2007-2018)
11. Sum emissions from electric vehicles and remaining diesel vehicles
12. Calculate emissions reduction by subtracting reduction measure emissions from baseline
13. Divide emissions reduction by total transport emissions for percent sector reduction
14. Divide emission reduction by total state emissions for percent state reduction

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LIDAC Calculations

Adopting zero emission medium – and heavy-duty vehicles may benefit 774,595 community members who are disadvantaged due to a health or transportation burden, equivalent to 11 percent of Massachusetts population.

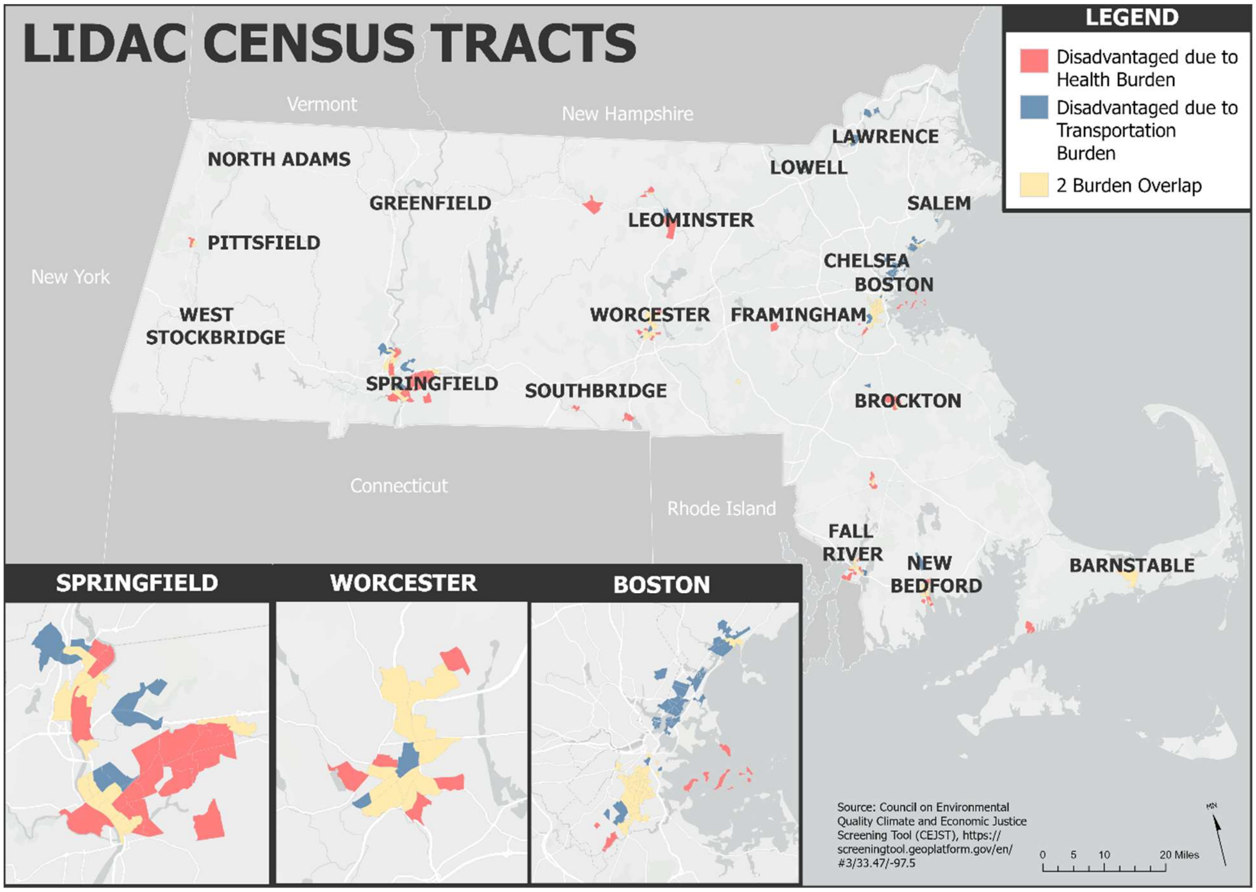

Figure 21: Health and Transportation Burdened Census Tracts

Appendix D – T2. Adopt Zero Emission Light-Duty Vehicles

Funding Intersections

- MassDEP provides U.S. EPA Diesel Emissions Reduction Act (DERA) funding
- Massachusetts Electric Vehicle Incentive Program (MassEVIP)
- Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Program
- Utility Incentives from Eversource, National Grid, Braintree Electric Light Department, and Shrewsbury Electric and Cable Operations

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including but not limited to the Massachusetts DOER, MassCEC, MassDEP, Massachusetts DPU, Massachusetts EEA, DCAMM, MassDOT
- Tribal Nations

Implementation Schedule and Milestones

Massachusetts is pursuing the major milestones of reducing transportation emissions 18% by 2025 and 34% by 2030 from 1990 levels. Light-duty vehicles make up the largest slide of the transportation sector's emissions. Massachusetts committed to 300,000 ZEVs registered in the state by 2025 as part of the Multi State ZEV Taskforce. Modeling form the CECP projects a target of 1,000,000 light-duty EVs by 2030, or about 19% of the total light-duty vehicle fleet.

Expected Geographic Location

Statewide

Milestones for Obtaining Legislative or Regulatory as Appropriate

Low/Zero Emission Passenger Vehicles: The Department of Energy Resources currently administers the MOR-EV Program for light-, medium- and heavy-duty vehicles Statutory authority for the Department of Energy Resources to administer an electric vehicle incentive program, including light-duty vehicles, is provided in MGL.c.25A § 19 with program regulations in 225 CMR 26.00. State procurement of electric vehicles is conducted under MGL c. 30, § 51 and by Executive Order 594. Municipal authority to procure vehicles is governed by c.30B.

Metrics for Tracking Progress

- Air quality measurements along major highways and interstates
- Number of light-duty vehicle registrations in MA that are electric, and percent of total light-duty vehicle fleet that is electric

- Number of installed electric vehicle public charging ports
- Vehicle Miles Traveled (VMT) for all light-duty vehicles

GHG Reduction Methodology

1. Use Massachusetts Vehicle Census MassVehicleCensus | GeoDOT (arcgis.com) for fossil fuel light-duty vehicle counts, and daily VMT from 1/1/2020.
    a. Light-duty: 3,198,637 vehicles, 82,172,657 daily VMT
    b. Unknown: 1,602,948 vehicles, 40,860,089 daily VMT
2. Unknown vehicles are assumed to be light-duty or passenger vehicles.
3. Using Mass Vehicle Census Data – Advanced Vehicle Type table, assume all Class 1 vehicles are "passenger" and all Class 2 vehicles are "light-duty"
    a. Calculate percent breakdown between passenger and light-duty
    b. Light duty trucks = 19.2%, passenger = 80.8%
4. Apply this percent breakdown to total light duty and "unknown" vehicles from Mass Vehicle Census.
    a. Passenger vehicles = 3,879,703 vehicles, 99,411,025 daily VMT
    b. Light-Duty = 921,882 vehicles, 23,621,721 daily VMT
5. All passenger and light-duty vehicles are assumed to be gasoline vehicles
6. Use Department of Energy, 2020: Average Fuel Economy by Major Vehicle Category for average gasoline mpg assumptions.
    a. Passenger: 24.2 mpg (taken from "Car")
    b. Light duty vehicles: 17.5 mpg (taken from "Light Truck/Van")
7. Calculate annual gallons of fuel using average mpg and annual VMT values

$$\frac{\text{Annual VMT}}{\text{average mpg}} = \text{Annual gallons of fuel}$$

8. Calculate baseline emissions
    a. Use 2020 EPA GHG Emission Factors Hub for kg CO2/gallon, g CH4/mile, g N2O/mile
    b. For CO2, use motor gasoline fuel factor:
        i. 8.78 kg CO2/gallon
    c. For CH4, N2O, assume gasoline passenger and light-duty vehicles in vehicle year: (2010):
        i. Passenger cars:
            1. 0.0071 g CH4/mile, 0.0046 g N2O/mile
        ii. Light-duty:
            1. 0.0095 g CH4/mile, 0.0035 g N2O/mile
9. Calculate CO2e using factors in 2020 EPA GHG Emission Factors Hub
    a. 1 kg CO2 = 1 kg CO2e
    b. 1 kg CH4 = 25 kg CO2e
    c. 1 kg N2O = 298 kg CO2e
10. Assume 15% of passenger and light-duty vehicles electrify
11. Calculate electricity use from converted electric vehicles

a. Use California Air Resources Board, 2018 Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles
b. Light Duty (Class 1-2): 0.5 kWh/mile

12. Use grid emissions factor (412 lbCO2e/MWh) to calculate emissions associated with electric vehicles
13. Calculate greenhouse gas emissions from remaining gallons of gasoline
    a. 90% of gallons of gasoline, 90% of VMT
    b. Use 2020 EPA GHG Emission Factors Hub for kg CO2/gallon, g CH4/mile, g N2O/mile
    c. For CO2, use motor gasoline fuel factor:
        i. 8.78 kg CO2/gallon
    d. For CH4, N2O, assume gasoline passenger and light-duty vehicles in vehicle year: (2010):
        i. Passenger cars:
            1. 0.0071 g CH4/mile, 0.0046 g N2O/mile
        ii. Light-duty:
            1. 0.0095 g CH4/mile, 0.0035 g N2O/mile
14. Sum emissions from electric vehicles and remaining diesel vehicles
15. Calculate emissions reduction by subtracting reduction measure emissions from baseline
16. Divide emissions reduction by total transport emissions for percent sector reduction
17. Divide emission reduction by total state emissions for percent state reduction

LIDAC Calculations

Adopting zero emission light-duty vehicles may benefit 774,595 community members who are disadvantaged due to a health or transportation burden, equivalent to 11 percent of Massachusetts population.

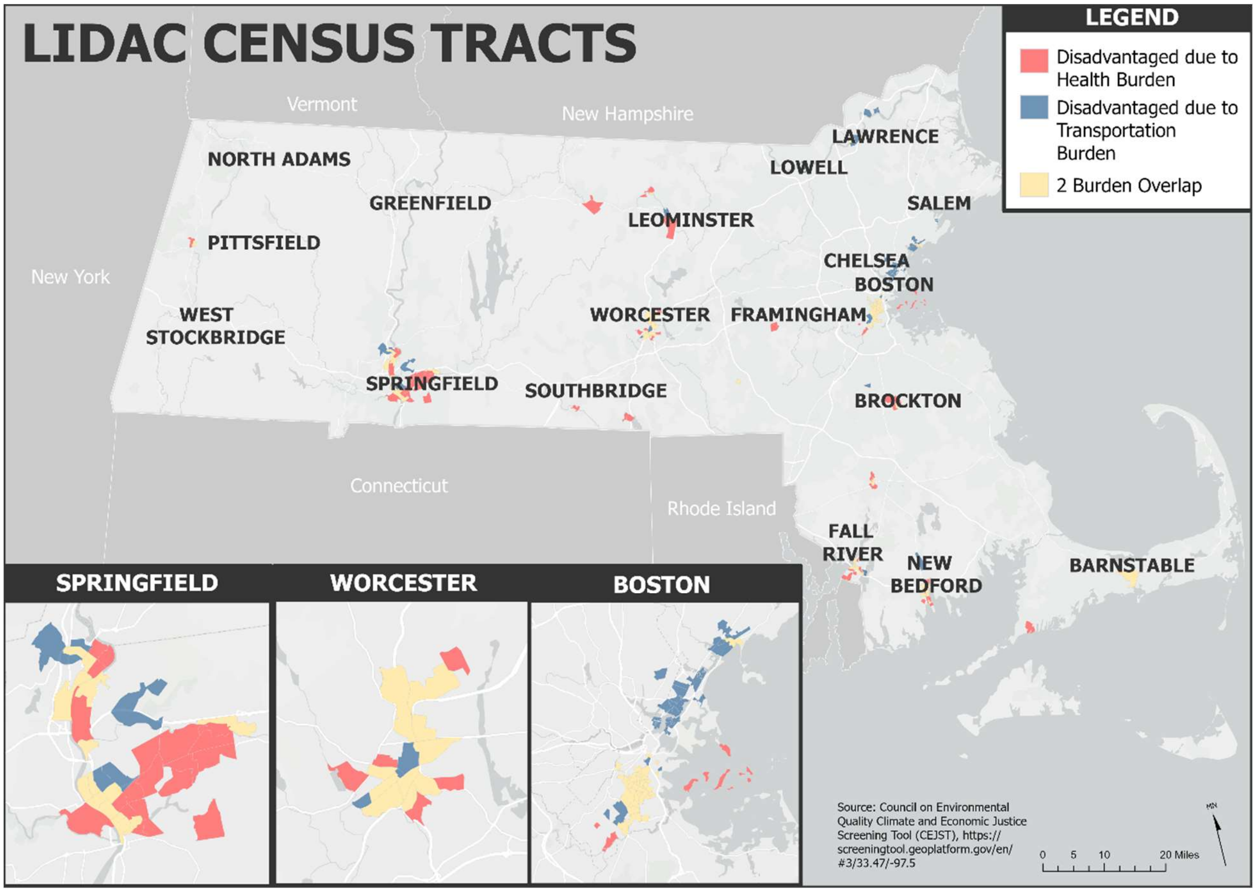

Figure 22: Health and Transportation Burdened Census Tracts

Appendix E – T3. Increase Alternatives to Personal Vehicle Use

Funding Intersections

- Bipartisan Infrastructure Law (BIL)
- U.S. DOT's Multimodal Project Discretionary Grant (MPDG)
- U.S. DOT's Reconnecting Communities and Neighborhoods Grant Program (RCN)
- MassDOT's Community Transit Grant Program.
- MassDOT's Complete Streets
- Massachusetts Community Health and Healthy Aging Funds
- Massachusetts Community Development Block Grant (CDBG)

Key Implementing Agency or Agencies

- Municipalities
- Regional Transit Authorities
- State agencies and quasi-agencies, including but not limited to: MassCEC, MassDOT, Executive Office of Housing and Livable Communities, EEA, MBTA, and MassDEP
- Tribal Nations

Implementation Schedule and Milestones

Implementation will depend on the funding available. Funding from sources such as the IIJA and the BIL will determine the rate at which the Commonwealth can implement projects that increase alternatives to personal vehicle use.

The state is currently aiming to electrify the entire bus fleet for the MBTA by 2040 with interim goals of electrifying one third of the fleet by 2028 and half of the fleet by 2030 with goals to also electrify the Massachusetts rail network. Furthermore, it is projected from the Massachusetts CECP that there will be a targeted decrease in VMT per household of 3% by 2030.

Expected Geographic Location

Statewide with a focus on LIDAC communities

Milestones for Obtaining Legislative or Regulatory as Appropriate

Implementing Entity: Massachusetts Bay Transit Authority

Expand and Electrify Rail Service: In Massachusetts, commuter rail service is provided by the Massachusetts Bay Transit Authority under statutory authority established in M.G.L. c. 161A § 3 (i).

Metrics for Tracking Progress

- Total Vehicle Miles Traveled (VMT) by mode, and VMT per household
- Number of E-Bike Sales in Massachusetts
- Miles of safe bike trail infrastructure
- Number of rail trips and number of passengers traveling by rail (commuter rail, regional rail, rapid transit)
- Number of electric ferries in Massachusetts
- Number of electric transit buses and percent of transit buses that are electric
- Percent of service that has been electrified for each mode
- Air quality measurements along major highways and interstates

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Methodology

1. Use Massachusetts Vehicle Census MassVehicleCensus | GeoDOT (arcgis.com) for fossil-fuel light duty vehicle counts, and daily VMT from 1/1/2020.
    a. Light duty: 3,198,637 vehicles, 82,172,657 daily VMT
    b. Unknown: 1,602,948 vehicles, 40,860,089 daily VMT
2. Unknown vehicles are assumed to be light duty or passenger vehicles.
3. Using Mass Vehicle Census Data – Advanced Vehicle Type table, assume all Class 1 vehicles are "passenger" and all Class 2 vehicles are "light duty"
    a. Calculate percent breakdown between passenger and light duty
    b. Light duty trucks = 19.2%, passenger = 80.8%
4. Apply this percent breakdown to total light duty and "unknown" vehicles from Mass Vehicle Census.
    a. Passenger vehicles = 3,879,703 vehicles, 99,411,025 daily VMT
5. All passenger vehicles are assumed to be gasoline vehicles
6. Use Department of Energy, 2020: Average Fuel Economy by Major Vehicle Category for average gasoline mpg assumptions.
    a. Passenger: 24.2 mpg (taken from "Car")
7. Calculate annual gallons of fuel using average mpg and annual VMT values

$$= Annual\ gallons\ of\ fuel$$

8. Calculate baseline emissions
    a. Use 2020 EPA GHG Emission Factors Hub for kg CO2/gallon, g CH4/mile, g N2O/mile
    b. For CO2, use motor gasoline fuel factor:
        i. 8.78 kg CO2/gallon
    c. For CH4, N2O, assume gasoline passenger and light-duty vehicles in vehicle year: (2010):
        i. Passenger cars:
            1. 0.0071 g CH4/mile, 0.0046 g N2O/mile
        ii. Light-duty:
            1. 0.0095 g CH4/mile, 0.0035 g N2O/mile

9. Calculate CO2e using factors in [2020 EPA GHG Emission Factors Hub]
    a. 1 kg CO2 = 1 kg CO2e
    b. 1 kg CH4 = 25 kg CO2e
    c. 1 kg N2O = 298 kg CO2e
10. Assume 3% of passenger vehicle emissions reduction by mode-shift to active transit
11. Calculate emissions reduction by subtracting reduction measure emissions from baseline
12. Divide emissions reduction by total transport emissions for percent sector reduction
13. Divide emission reduction by total state emissions for percent state reduction

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LIDAC Calculations

Increasing alternative options to personal vehicle use may benefit 514,121 community members who are disadvantaged due to a transportation burden, equivalent to 7 percent of Massachusetts population.

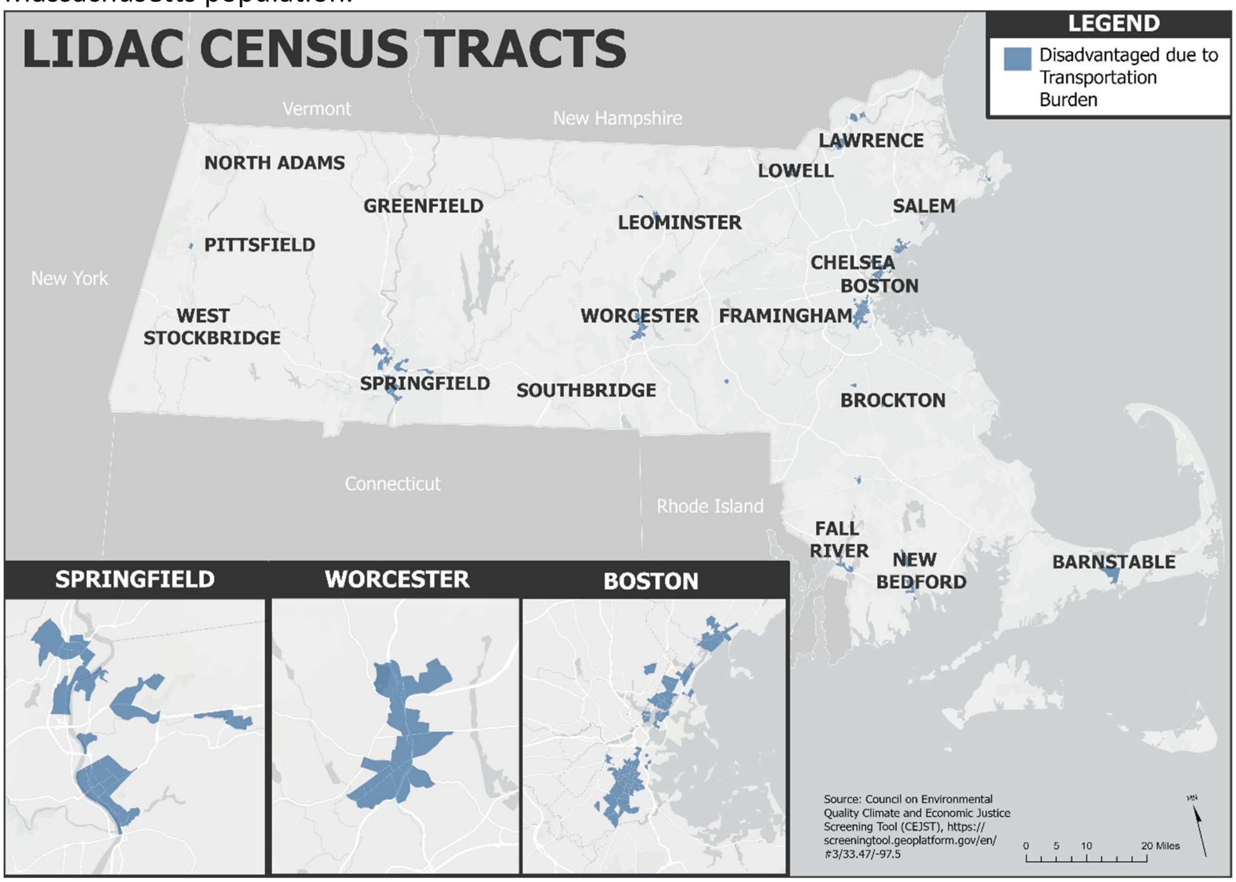

Figure 23: Transportation Burdened Census Tracts

Appendix F – B1. Increase Building Efficiency

Funding Intersections

- Federal Energy Efficient Home Improvement Credit
- Department of Energy Home Performance-Based, Whole House Rebates
- Department of the Treasury Energy Efficient Commercial Buildings Deduction
- IRS Energy Efficient Home Improvement Credit, New Energy Efficient Homes Credit
- Mass Save®
- Department of the Treasury Energy Efficient Commercial Buildings Deduction
- Federal Weatherization Assistance Program
- IRS Energy Efficient Home Improvement Credit, New Energy Efficient Homes Credit

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including but not limited to MassCEC, DOER, MassHousing, EEA
- Tribal Nations

Implementation Schedule and Milestones

Implementation will depend on ongoing funding availability in line with building electrification targets. Implementation of building efficiency needs to be aligned with CECP heat pump schedule and milestones in B2.

Expected Geographic Location

Statewide with a focus on older building stock.

Milestones for Obtaining Legislative or Regulatory as Appropriate

Renovate/ Retrofit existing commercial buildings: Statutory authority for the Executive Office of Energy and Environmental Affairs to promulgate programs that reduce greenhouse gas emissions and to manage an energy efficiency program rest in MGL.c.8 § 6 and c.25 § 19 and § 21.

Renovate/ Retrofit existing housing stock: There are multiple existing programs for state agencies to renovate existing housing stock. Statutory authority for the Executive Office of Energy and Environmental Affairs to promulgate programs that reduce greenhouse gas emissions and to manage an energy efficiency program rest in MGL.c.8 § 6 and c.25 § 19 and § 21.

Renovate/ Retrofit existing schools: The roles of municipalities in seeking funding and the Massachusetts School Board Authority in providing financial assistance for construction and improvement projects are lain out in M.G.L. 70B § 1 - School building assistance program; and M.G.L. 10 § 35BB - School Modernization and Reconstruction Trust Fund.

Metrics for Tracking Progress

- Number of residential energy audits and weatherization projects by types of building stock
- Amount of funding for building energy efficiency spent in LIDAC communities
- Number of people employed in occupations servicing residential and commercial energy efficiency (Insulation Workers, General Operations Managers, Building Inspectors, and other occupations), and number of new jobs needed to meet demand and state decarbonization goals
- Energy use intensity (EUI) and carbon use intensity (CUI) by residential and commercial building type

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Methodology

1. Use Massachusetts building square footage data for residential and commercial buildings and homes: Building Sector Report December 2020
    a. Total residential square footage: 4,333,768,520 square feet
    b. Total commercial square footage: 1,690,106,777
2. Use baseline Scope 1 emissions from Massachusetts 2019 annual inventory
    a. Residential: 13.74 MMTCO2e
    b. Commercial: 8.07 MMTCO2e
3. Use EIA Tables Total End-Use Sector Energy Consumption Estimates, Massachusetts
    a. Residential percent of total state electricity use: 62%
    b. Commercial percent of total state electricity use: 30%
4. Use EEA Summary of Massachusetts electric load from 2019:
    a. 56,628,281 MWh
5. Calculate Scope 1 and Scope 2 emissions per square foot for commercial and residential buildings
6. Calculate baseline Scope 1 and Scope 2 emissions for implementation percentages:
7. ~28% of all commercial buildings, including municipal buildings and schools, implement retrofits
8. ~24% of single family homes & residential buildings implement retrofits
9. Use NREL Slope Data for Massachusetts specific fuel and electricity reductions from implementing:
    a. Heat recovery for commercial buildings (including municipal and school buildings)
    b. Envelope upgrades including window film, roof insulation, wall insulation for commercial and residential buildings
    c. Lighting upgrades for residential and commercial buildings
10. Calculate emissions reduction from baseline for electricity and fuel savings separately

11. Sum emissions reduction for each building efficiency measure for each group of buildings (schools, municipal, residential, remaining commercial)
12. Divide emissions reduction by total Scope 1 buildings (21.76 MMTCO2e), and Scope 2 for electricity generation (10.72 MMTCO2e) for percent sector reductions
13. Divide emission reduction by total state emissions for percent state reduction

LIDAC Calculations

Increasing building efficiency may benefit 1,230,227 community members who are disadvantaged due to a energy, health, or workforce development burden, equivalent to 18 percent of Massachusetts population.

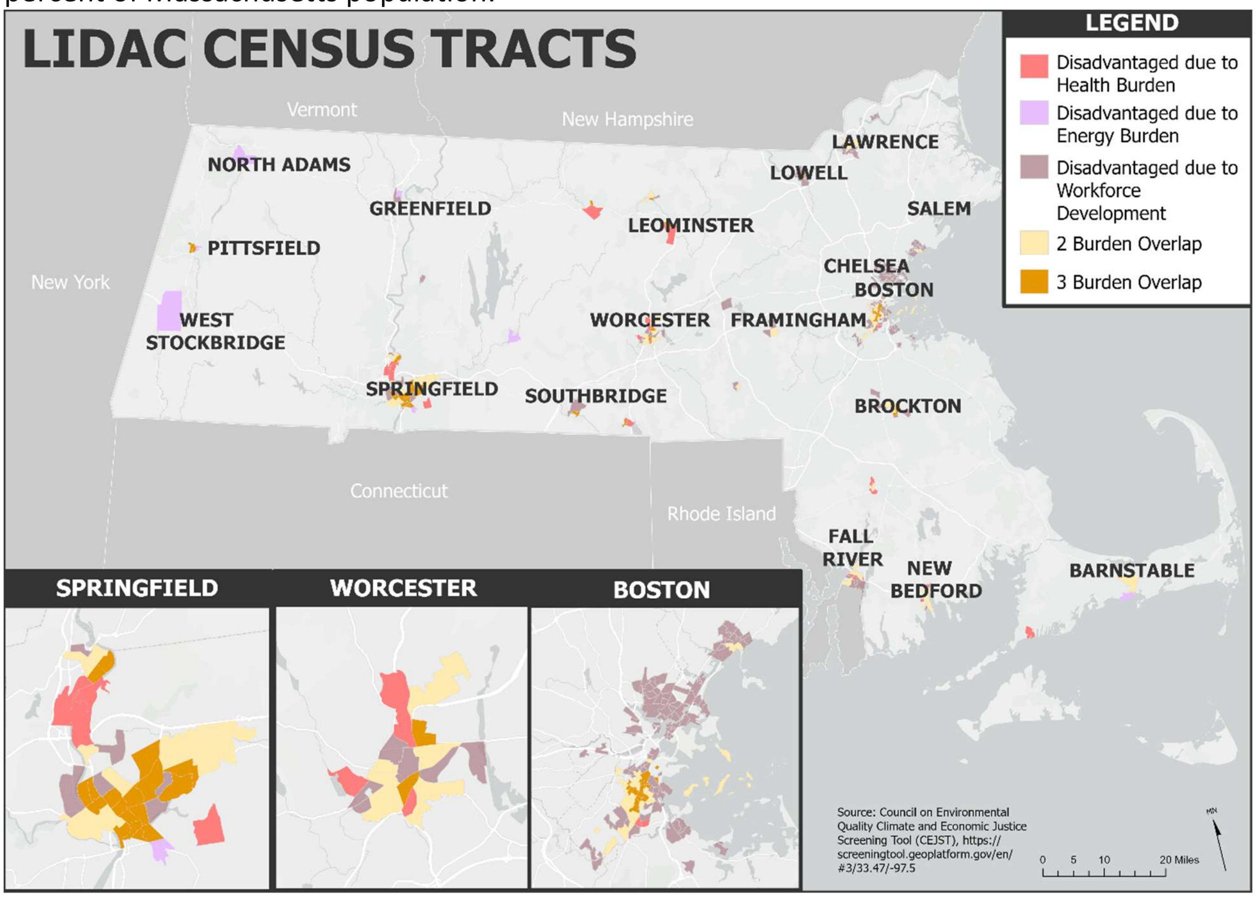

Figure 24: Energy, Health, and Workforce Development Burdened Census Tracts

Appendix G – B2. Decarbonize Building Heating Systems

Funding Intersections

- IRS Investment Tax Credit
- DOE State-Based Home Efficiency Contractor Training Grants
- City of Boston Large Building Green Energy Retrofits Program, funded from the federal American Rescue Plan Act
- Mass Save
- MassCEC
- Federal Home Energy Rebates Program and Home Electrification and Appliance Rebate Program

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including but not limited to MassCEC, DOER, MassHousing, EEA
- Tribal Nations

Implementation Schedule and Milestones

- Massachusetts mandates emissions reductions of 50% in residential heating and cooling by 2030, and 49% in commercial & industrial heating and cooling compared to 1990 levels.
- The 2025/2030 CECP projects a target for heat pump installations in at least 100,000 homes between 2020 and 2025 and at least 500,000 homes between 2020 and 2030.
- CECP also sets a target of at least 300,000 sq. ft of commercial space retrofitted with heat pumps between 2020 and 2030.

Expected Geographic Location

Statewide with a focus on older building stock and new construction.

Milestones for Obtaining Legislative or Regulatory as Appropriate

Increase Heat Pump Adoption: Statutory authority for the Executive Office of Energy and Environmental Affairs to promulgate programs that reduce greenhouse gas emissions including heat pumps rests in MGL.c.8 § 6 and c.25 § 19 and § 21. See also the Order in DPU 20-80.

Expand Geothermal Adoption: Under M.G.L. c. 179 § 7. geothermal systems, including network geothermal and renewable district heat are included in the definition of "clean energy" systems eligible for the creation of programs and incentives under MGL.c.8 § 6 and c.25 § 19 and § 21.

Metrics for Tracking Progress

- Number of residential air source heat pump installations per year
- Number of commercial buildings with air source heat pump installations per year
- Number of residential geothermal heat pump installations per year
- Number of commercial buildings with geothermal heat installations per year
- Number of people employed in occupations servicing building heat and water decarbonization (including HVAC Mechanics and Installers, General Operations Managers, Pipelayers, Plumbers, Pipefitters, Steamfitters, and other occupations), and number of new jobs needed to meet demand and state decarbonization goals.
- Percent of buildings with electric or geothermal heating
- Energy use intensity (EUI) and carbon use intensity (CUI) by residential and commercial building type

---

Methodology

1. Use Massachusetts building square footage data for residential and commercial buildings and homes: Building Sector Report December 2020
    a. Total residential square footage: 4,333,768,520 square feet
    b. Total commercial square footage: 1,690,106,777
2. Use baseline Scope 1 emissions from Massachusetts 2019 annual inventory
    a. Residential: 13.74 MMTCO2e
    b. Commercial: 8.07 MMTCO2e
3. Use EIA Tables Total End-Use Sector Energy Consumption Estimates, Massachusetts
    a. Residential percent of total state electricity use: 62%
    b. Commercial percent of total state electricity use: 30%
4. Use EEA Summary of Massachusetts electric load from 2019:
    a. 56,628,281 MWh
5. Use total number of housing units in Table 21 from Massachusetts from Massachusetts 2050 Decarbonization Roadmap: 2,830,000 housing units
6. Use EIA data for New England housing units from 2020 from Table CE4.1: Annual household site end-use consumption by fuel in the United States and scale fuel use data for space and water heating on MMBtu/housing unit basis to Massachusetts
7. Calculate baseline Scope 1 and Scope 2 emissions for implementation percentages:
    a. 19.83% of housing units electrify space and water heating with air source heat pumps
    b. 24.03% of commercial buildings electrify space and water heating with air source heat pumps
    c. 4.49% of housing units electrify heating with geothermal heat pumps
    d. 3.86% of commercial buildings electrify heating with geothermal heat pumps
8. Assume fuel use for heating in commercial buildings is by natural gas, with an equipment efficiency of 80%
9. Assume fuel split for heating in Massachusetts per EIA household energy use data, assume fuel equipment efficiencies:
    a. Natural gas: 80%

b. Fuel oil: 60%
c. Propane: 80%

10. Assume electrified heating equipment efficiencies:
    a. Average air-source heat pump COP: 3.22
    b. Average ground-source heat pump COP: 5
11. Calculate emissions reduction from baseline for electricity and fuel savings separately
12. Divide emissions reduction by total Scope 1 buildings (21.76 MMTCO2e), and Scope 2 for electricity generation (10.72 MMTCO2e) for percent sector reductions
13. Divide emission reduction by total state emissions for percent state reduction

LIDAC Calculations

Decarbonizing building heating systems may benefit 254,899 community members who are disadvantaged due to an energy burden, equivalent to 4 percent of Massachusetts population.

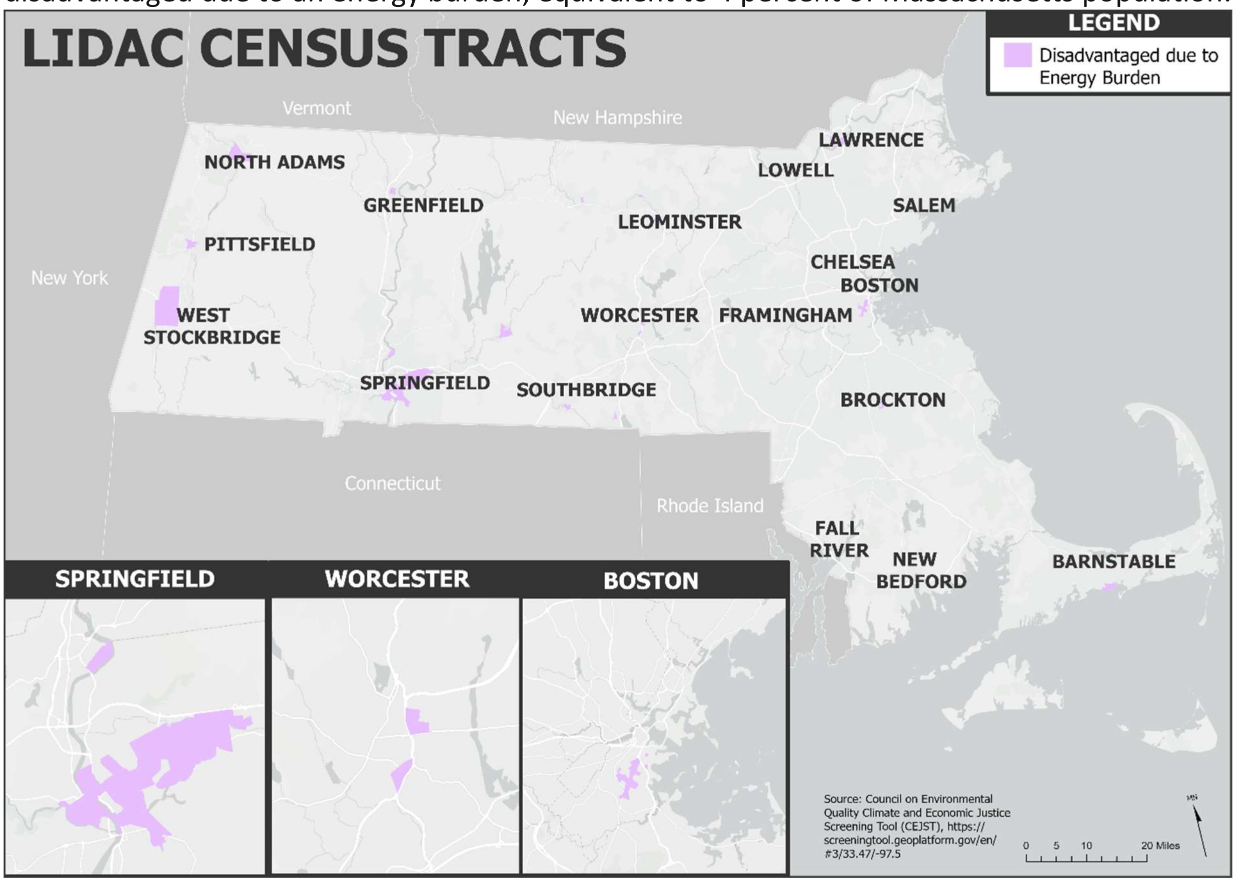

Figure 25: Energy Burdened Census Tracts

Appendix H – P1. Develop New Renewable Energy Facilities

Funding Intersections

- IRS Clean Electricity Production Tax Credit, Clean Electricity Investment Tax Credit, Production Tax Credit (PTC)
- Massachusetts Clean Energy Center (MassCEC)
- Mass Save
- Solar Massachusetts Renewable Target (SMART) Program
- IRS Clean Electricity Production Tax Credit, Clean Electricity Investment Tax Credit, Production Tax Credit (PTC)
- Massachusetts DOER Renewable Energy Portfolio Standard Alternative Compliance Payments

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies, including but not limited to DOER, DPU, and MassCEC
- Tribal Nations

Implementation Schedule and Milestones

- For the electric power sector, Massachusetts mandates emissions reductions of 53% by 2025, and 70% by 2030 compared to 1990 levels.
- The 2025/2030 CECP modeling estimates 180 MW of wind capacity (all onshore) in 2025 and 3,650 MW of wind capacity (onshore and offshore combined) in 2030.
- The 2025/2030 CECP modeling estimates 4,470 MW alternating current (AC) of solar capacity by 2025 and 8,360 MW AC of solar capacity by 2030.
- CECP projects a target of 2.9 GW of storage by 2030.

Expected Geographic Location

Statewide with a focus on areas with high wind/solar potential.

Milestones for Obtaining Legislative or Regulatory as Appropriate

Accelerate Offshore Wind Development: Statutory authority for the Massachusetts Clean Energy Center to administer a program to develop offshore wind manufacturing and infrastructure facilities rests in MGL.c. 23J § 8A.

Increase Solar PV Development: Statutory authority for the Department of Energy Resources to administer a solar energy incentive program rests in M.G.L. c. 21N § 1 through 9 and in 225 CMR 20.00.

Metrics for Tracking Progress

- Percentage of state electricity consumption met with clean power
- Renewable Energy generation capacity, including wind, solar, and storage capacity
- Tons of CO_2 emitted from electric power generation
- Percent of buildings with electric or geothermal heating
- Number of new wind turbines

Methodology

1. Use "Phased" scenario targets for new renewable energy facilities by 2030 from Massachusetts Clean Energy and Climate Plan for 2025 and 2030
    a. Onshore wind: 1 TWh annual generation
    b. Offshore wind: 13 TWh annual generation
    c. Solar PV: 13 TWh annual generation
2. Calculate equivalent CO2e emissions saved with 412 lbCO2e/MWh grid emissions factor to produce the same amount of electricity to calculate emissions reduction
3. Divide emissions reduction by total electricity generation sector baseline for percent sector reductions
4. Divide emission reduction by total state emissions for percent state reduction

LIDAC Calculations

Developing new renewable energy facilities may benefit 1,262,902 community members who are disadvantaged due to a energy, health, workforce development, or legacy pollution burden, equivalent to 18 percent of Massachusetts population.

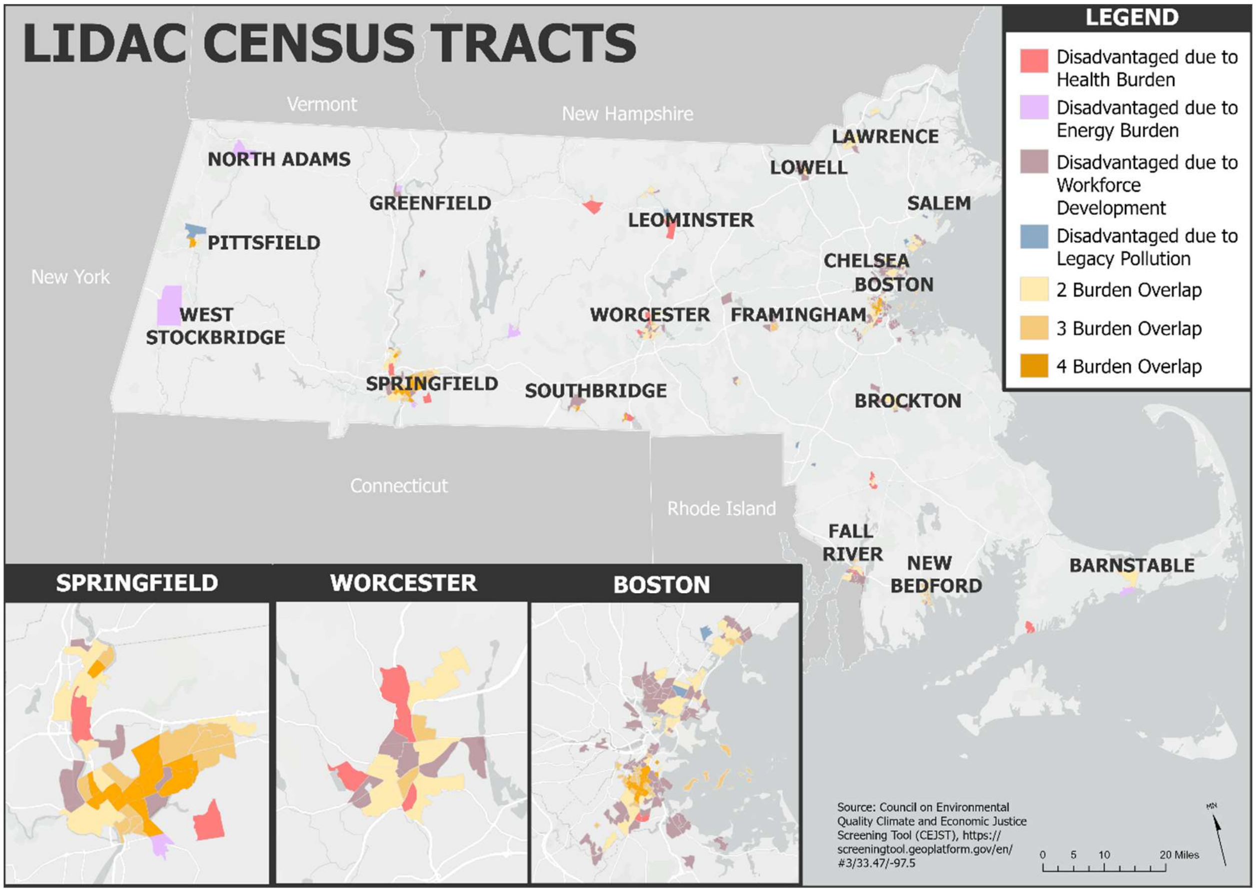

Figure 26: Energy, Health, Workforce Development, and Legacy Pollution Burdened Census Tracts

Appendix I – P2. Implement Building-Scale Renewables

Funding Intersections

- U.S DOE's Weatherization Assistance Program (WAP)
- Department of Energy High-Efficiency Electric Home Rebate Program
- IRS Residential Clean Energy Credit, High-Efficiency Electric Home Rebate Program, New Energy Efficient Homes Credit
- Department of House and Urban Development (HUD) Green and Resilient Retrofit Program - Grants and Loans
- Mass Save
- Massachusetts Clean Energy Center (MassCEC)
- MA Green Community Designation Grant Programs
- Solar Massachusetts Renewable Target (SMART)
- U.S DOE's Weatherization Assistance Program (WAP)
- Department of Energy High-Efficiency Electric Home Rebate Program
- IRS Residential Clean Energy Credit, High-Efficiency Electric Home Rebate Program, New Energy Efficient Homes Credit
- Department of House and Urban Development (HUD) Green and Resilient Retrofit Program - Grants and Loans

Key Implementing Agency or Agencies

- Municipal governments and affiliated organizations
- State agencies and quasi-agencies including DOER and MassCEC
- Tribal Nations

Implementation Schedule and Milestones

This measure follows the milestones noted in P1 for electric power sector decarbonization.

Expected Geographic Location

Statewide with a focus on LIDACs

Milestones for Obtaining Legislative or Regulatory as Appropriate

Install On-Site Renewable Energy: Statutory authority for the Department of Energy Resources to administer a solar energy incentive program rest in M.G.L. c. 21N § 1 through 9 and in 225 CMR 20.00.

Metrics for Tracking Progress

This measure will be evaluated by the metrics noted in P1 for electric power sector decarbonization. Additional metrics include:

- Percentage of residential homes with installed solar capacity, and total solar capacity installed at residential homes
- Percentage of commercial buildings with installed solar capacity, and total solar capacity at commercial buildings
- Quantity and acres of pilot neighborhoods/districts
- Number of new solar installations

Methodology

1. Solar PV:
    a. Assume 4 kW solar on homes, 50 kW solar on commercial buildings
    b. Use NREL's PVWatts for Boston location to estimate annual energy generation from 4 kW and 50 kW solar arrays
    c. Assume 5% of homes install 4 kW arrays, 10% of commercial buildings install 50 kW arrays
    d. Use Massachusetts building square footage data for residential and commercial buildings and homes: Building Sector Report December 2020
        i. Total residential single family: 2,843,224,178 square feet
        ii. Total commercial square footage: 1,690,106,777
    e. Assume average of 1,500 square foot homes to estimate number of homes, average of 10,000 square feet for commercial buildings to estimate number of commercial buildings
    f. Use average grid emissions factor: 412 lbCO2e/MWh to calculate emissions reduced from using solar generation instead of grid electricity
2. Distributed wind:
    a. Assume 12 kW turbines at commercial buildings, 4 kW turbines at homes
    b. Assume 20% capacity factor for wind in Massachusetts
    c. Use Massachusetts building square footage data for residential and commercial buildings and homes: Building Sector Report December 2020
        i. Total residential single family: 2,843,224,178 square feet
        ii. Total commercial square footage: 1,690,106,777
    d. Assume average of 1,500 square foot homes to estimate number of homes, average of 10,000 square feet for commercial buildings to estimate number of commercial buildings
    e. Use average grid emissions factor: 412 lbCO2e/MWh to calculate emissions reduced from using wind generation instead of grid electricity
    f. Divide emissions reduction by electricity generation for percent sector reductions

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LIDAC Calculations

Implementing building-scale renewables may benefit 1,230,227 community members who are disadvantaged due to an energy, health, or workforce development burden, equivalent to 18 percent of Massachusetts population.

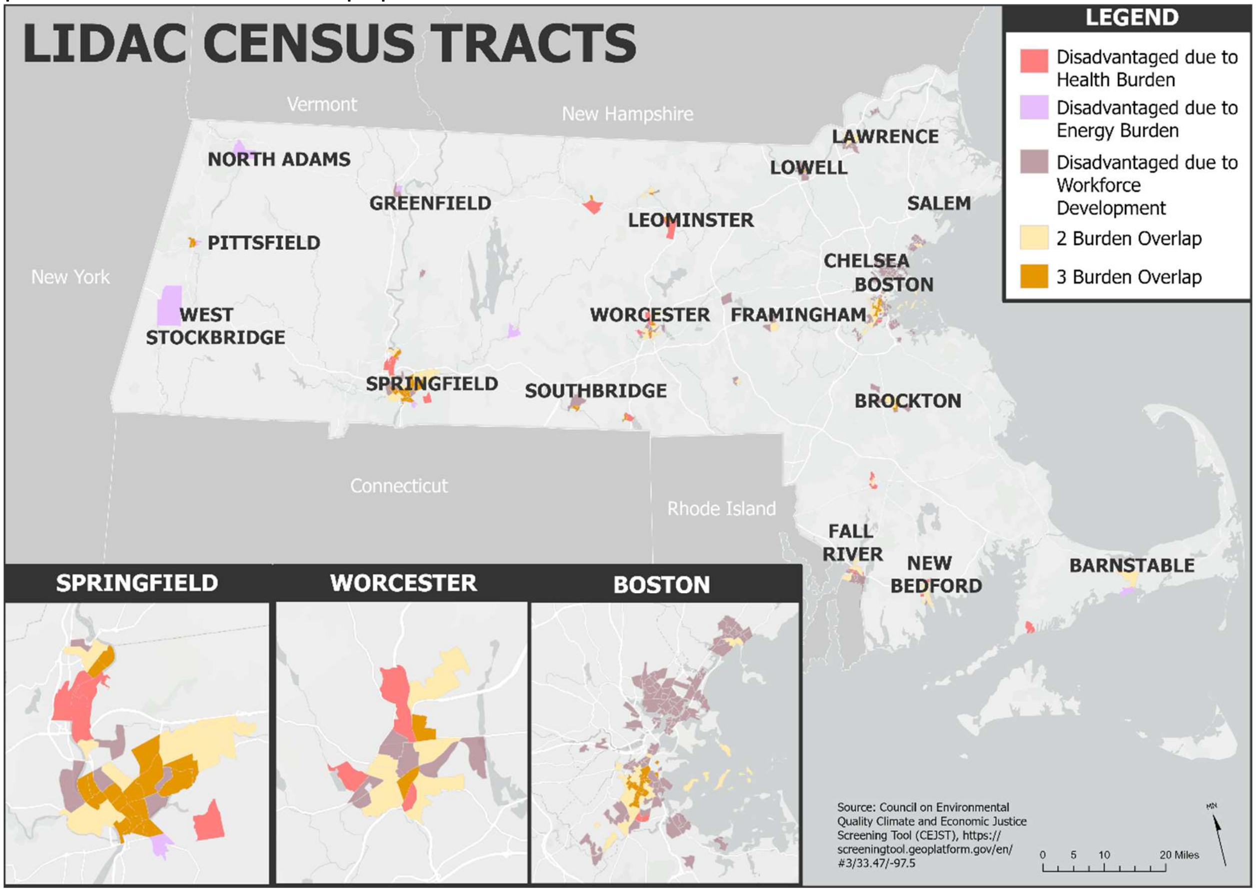

Figure 27: Energy, Health, or Workforce Development Burdened Census Tracts

Appendix J – P3. Maximize Utilization of Clean Energy

Funding Intersections

- Tax incentives provided by the IRA
- SMART, ConnectedSolutions, and various energy and ancillary services markets administered by ISO-NE
- Mass Save
- Third party energy service companies

- **Key Implementing Agency or Agencies**
- Municipalities
- State agencies and quasi-agencies including the DOER, DPU, and MassCEC
- Tribal Nations

Implementation Schedule and Milestones

This measure follows the milestones noted in P1 for electric power sector decarbonization.

Expected Geographic Location

Statewide with a focus on LIDACs

Milestones for Obtaining Legislative or Regulatory as Appropriate

Develop municipal microgrids: Massachusetts utility franchise law allows utilities the right of first refusal with regard to ownership and operation of infrastructure within "public ways" (streets). Therefore, community microgrid projects in the Commonwealth must be collaborative between utility and customers. See M.G.L. c. 164 § 1b (a) and § 34.

Implementing Entity: Municipal Light Plants and municipalities and state agencies in concert with electric utilities.

Electric grid investments: The requirements for electric system modernization plans for investor-owned utilities are detailed in M.G.L. c. 164 § 92B. and M.G.L. c. 164 § 34.

Metrics for Tracking Progress

- Percent of power loss through distribution and transmission
- Power capacity from municipal microgrids
- MWh of storage capacity

Methodology

1. Update electric utility infrastructure measure:
    a. Assume baseline emission from electricity generation includes 5.13% transmission losses as reported by EIA for Massachusetts in 2019
    b. Calculate 5.13% of baseline emissions from electricity generation
    c. Assume improvement by 50% from investing in new electric infrastructure improvements
    d. Calculate difference in emissions from baseline to get emissions reduction
    e. Divide emissions reduction by total electricity generation emissions for percent sector reductions
    f. Divide emission reduction by total state emissions for percent state reduction
2. Develop municipal microgrids measure:
    a. Assume (2) 400 kW microgrid, similar to Chelsea microgrid size
    b. Use NREL's PVWatts for Boston location to estimate annual energy generation from 400 kW solar array
    c. Assume 50% of solar generation is used directly as clean electricity
    d. Assume 50% of solar generation is used to charge battery and discharge during dirtiest grid time of use, assume controls are installed to optimize microgrid to discharge battery during times when grid has highest emissions factor to maximize emissions reductions
    e. Use highest grid emissions factor: 1,102 lbCO2e/MWh to calculate emissions reduced from using microgrid battery storage
    f. Use average grid emissions factor: 412 lbCO2e/MWh to calculate emissions reduced from using solar generation from microgrid during regular times
    g. Sum emissions reduced from solar generation and battery storage in microgrid
    h. Divide emissions reduction by electricity generation for percent sector reductions
    i. Divide emission reduction by total state emissions for percent state reduction
    j. Divide emission reduction by total state emissions for percent state reduction

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LIDAC Calculations

Maximizing utilization of clean energy may benefit 1,142,247 community members who are disadvantaged due to an energy or workforce development burden, equivalent to 16 percent of Massachusetts population.

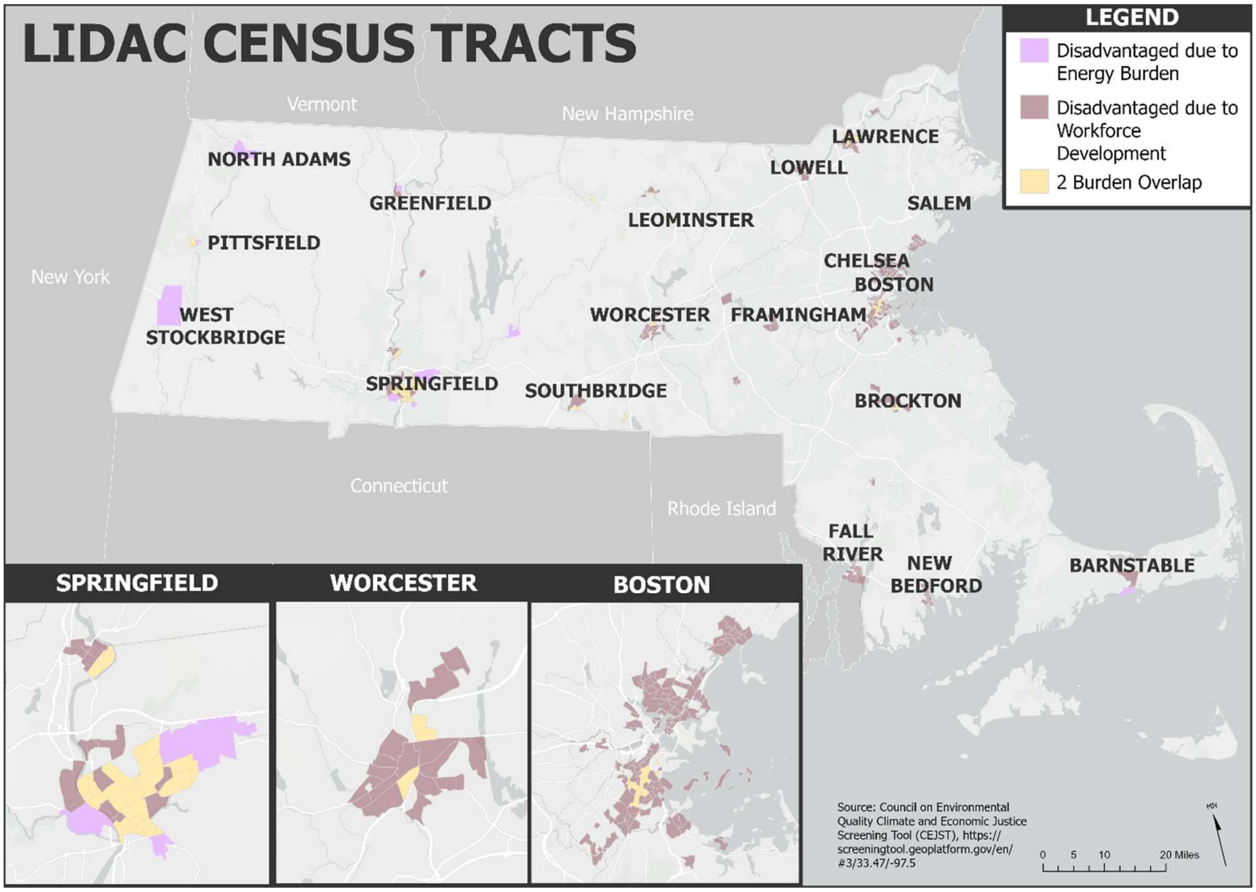

Figure 28: Energy or Workforce Development Burdened Census Tracts

Appendix K – N1. Implement Nature-based Solutions

Funding Intersections

- American Rescue Plan Act funding for land conservation
- Greening the Gateway Cities Implementation Grant Program and supporting partnership program through MA State Agencies
- The EEA with state and federal funding sources such as the Land and Water Conservation Fund
- State funding for the Riparian Tree Planting Program will be complimented by the Conservation Reserve or Environmental Incentives Programs or other U.S. Department of Agriculture (USDA) landowner cost share programs

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including by not limited to DCR, DFG, MDAR, and EEA
- Tribal Nations

Implementation Schedule and Milestones

The Commonwealth aims to permanently conserve 28% of natural working lands by 2025, 30% by 2030, and 40% by 2050. These goals translate to approximately 167,000 acres and 685,000 acres through 2030 and 2050 that will be conserved or permanently protected from development. 137,742 and 564,988 of these acres will be protected forest land in 2030 and 2050 respectively. Furthermore, the state plans to plant 5,000 acres of new urban and riparian trees by 2025 and 16,100 acres of new and urban riparian trees by 2030.

Expected Geographic Location

Statewide with a focus on preserving natural lands and LIDACs

Milestones for Obtaining Legislative or Regulatory as Appropriate

Increase Restorative Planting: The definition of nature-based solutions and inclusion of their GHG emission reduction potential in state planning is defined in MGL c. 21A § 1 and § 3A.

Metrics for Tracking Progress

- Percentage of Massachusetts' lands permanently conserved
- Tree canopy coverage
- Number of trees planted
- MMTCO2e sequestered by natural working lands

Methodology

1. Determine additional emissions sequestered from new planting.
   a. Assume additional acres of new urban and riparian tree canopy to be 16,100 acres in 2030 and 64,400 acres in 2050 according to the goals outlined in the Massachusetts CECP.
   b. Assume half the acreage mentioned above is allocated for new urban and riparian tree canopy and half the acreage is allocated for tree planting in urban areas such as streets and parks.
   c. Using the sequestration rate values from the Forest Ecosystem Yield Tables by Smith et al., find the amount of CO2e sequestered of newly planted forest. Multiply the acreage by the shorter-term average sequestration rate (19.2 tCO2/ac/yr.) for the years before 2030, and the longer-term average sequestration rate for 2030-2050 (26.1 tCO2/ac/yr.).
   d. For the acreage of new tree plantings allocated to urban areas, assume 50 trees are planted per acre.
   e. Using the weighted average sequestration rate of 6.1 kgCO2/tree/yr. from the EPA Greenhouse Gases Equivalencies Calculator, calculate the emissions sequestered through urban planting per year.
   f. Convert both the emissions sequestered from urban and reforestation planting numbers to MMT or MT CO2e and add together for each year from 2025-2050 for a cumulative total.
2. Determine additional emissions sequestered from newly protected forested land.
   g. Assume 137,742 additional acres of forested land will be protected by 2030 and 564,988 acres of forested land will be protected by 2050 according to the goals outlines in the Massachusetts CECP.
   h. Assume a linear progression of forest protection from 2025-2030, and 2030-2050.
   i. Multiply the acreage of protected land by the statewide forest carbon sequestration rate of 1.55 MTCO2e/acre/year to determine the amount of CO2e sequestered every year.
   j. Sum the sequestration values for every year to obtain a cumulative reduction value.
3. Sum the emissions reduction values from the new protected forested land and the additional planting to obtain total reduction values.

LIDAC Calculations

Implementing nature-based solutions may benefit 638,790 community members who are disadvantaged due to a health or climate change burden, equivalent to 9 percent of Massachusetts population.

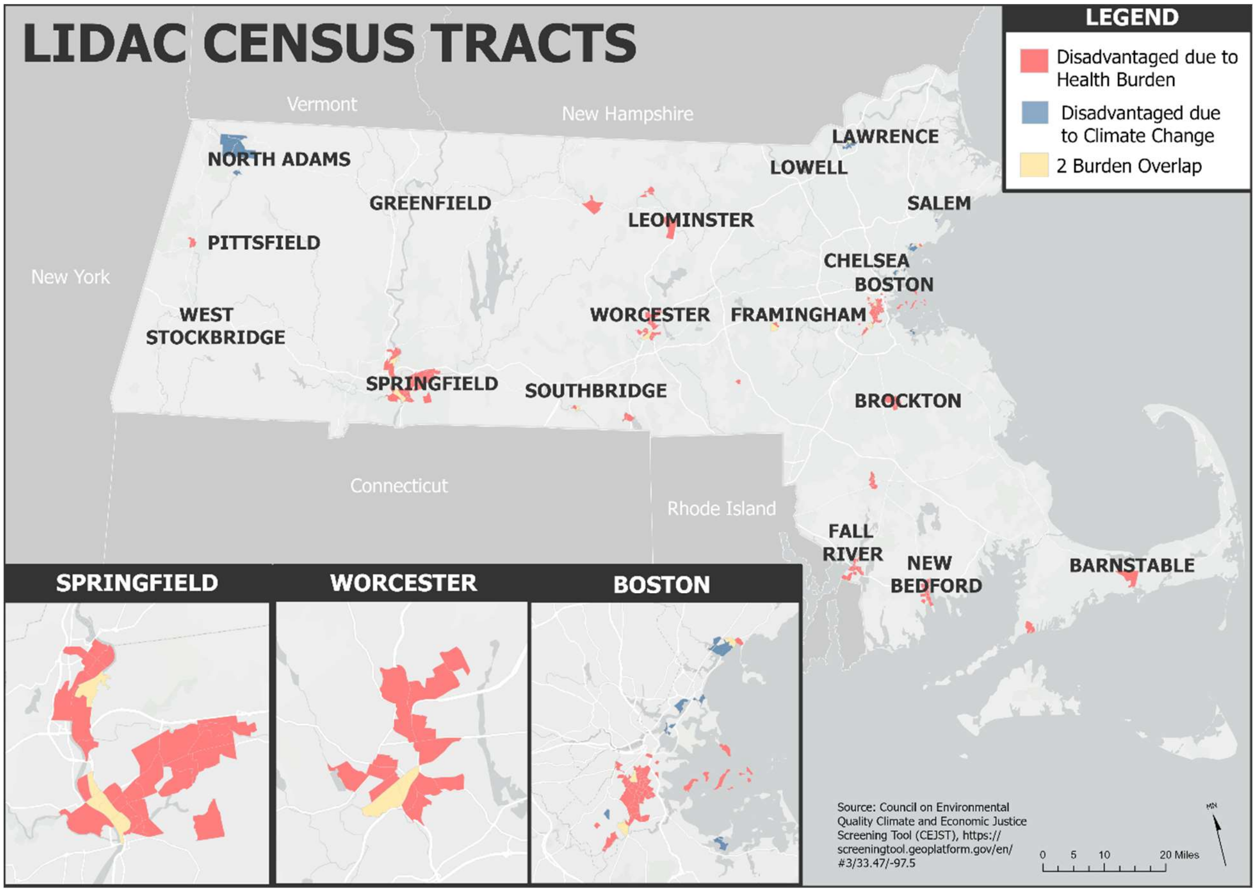

Figure 29: Health or Climate Change Burdened Census Tracts

Appendix L – W1. Reduce Organic Waste Through Composting

Funding Intersections

- Composting and Food Waste Reduction (CFWR) Cooperative Agreements from the USDA
- MassDEP Sustainable Materials Recover Program (SMRP)

Key Implementing Agency or Agencies

- Municipalities
- State agencies and quasi-agencies including MassDEP
- Tribal Nations

Implementation Schedule and Milestones

Massachusetts is committed to reducing solid waste by 30 percent in 2030, and 90 percent by 2050. To help achieve this goal, the Commonwealth is aiming to reduce the disposal of food and other organic materials by an additional 500,000 tons annually by 2030 from a baseline of 280,000 tons of food reduction in 2018. These goals are outlined in MassDEP's 2030 Solid Waste Master Plan.

Expected Geographic Location

Statewide with a focus on preserving natural lands and LIDACs.

Milestones for Obtaining Legislative or Regulatory as Appropriate

The authority to implement waste disposal needs is outlined in M.G.L. c. 16 § 21. The Commonwealth's Comprehensive Statewide Masterplan gives the authority to regulate solid waste disposal in line with the state's plan for solid waste.

Metrics for Tracking Progress

- Tons of food waste diverted from landfills and incinerators
- Tons of organic waste composted

Methodology

1. Assume food waste percentage of MSW from Massachusetts Solid Waste Master Plan: 21.5% food waste
2. Use Massachusetts Solid Waste Data for annual MSW tons: 570,000 tons in 2020
3. Calculate baseline food waste sent to landfill
    a. 122,550 tons

4. Use [California Air Resources Board – Method for Estimating GHG reductions from Diversion of Organic Waste from Landfills to Compost Facilities] to assign emissions factors to landfilled organic waste emissions and composted waste emissions
    a. 0.07 MTCO2e/ton for composted waste
    b. 0.385 MTCO2e/ton for landfilled organic waste
5. Assume 10% adoption; 10% of food waste diverted from landfills to compost facilities
6. Calculate baseline emissions from landfilled food waste
7. Calculate emissions from 10% food waste sent to composting facility
8. Sum emissions from 10% food waste composted and 90% food waste landfilled
9. Divide emissions reduction by waste emission for percent sector reduction
10. Divide emission reduction by total state emissions for percent state reduction

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LIDAC Calculations

Composting may benefit 1,105,180 community members who are disadvantaged due to a water and wastewater or workforce development burden, equivalent to 16 percent of Massachusetts population.

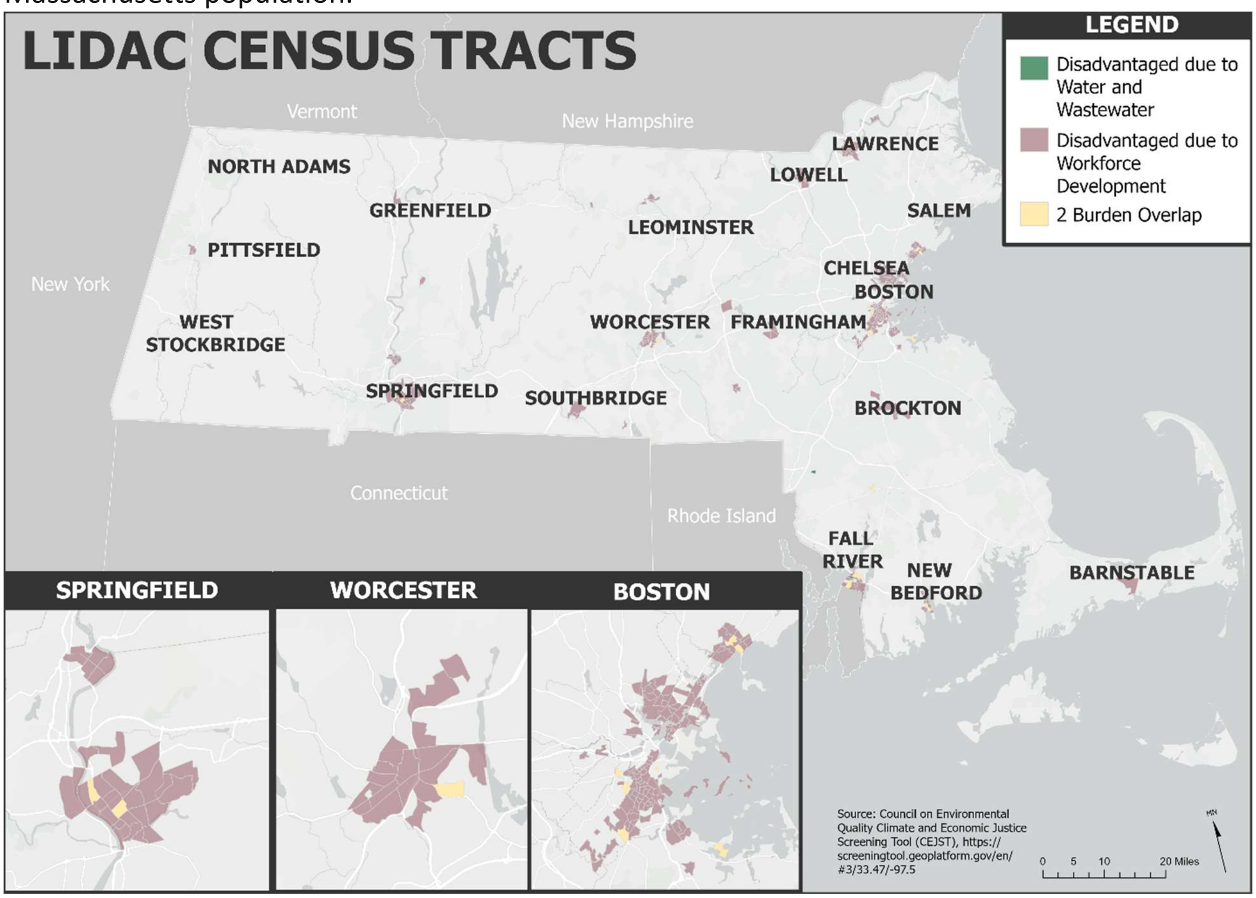

Figure 30: Health or Climate Change Burdened Census Tracts

Appendix M – CPRG Stakeholder Engagement Log

Date	Category	Group(s)	Meeting Topic	Attendance
7/5/2023	Municipal	Metropolitan Area Planning Council (MAPC)	CPRG Coordination & Collaboration	3
7/12/2023	Municipal	Southeastern Regional Planning & Economic Development District (SERPEDD)	CPRG Coordination & Collaboration	1
7/13/2023	Municipal	Central Massachusetts Regional Planning Commission (CMRPC)	CPRG Coordination & Collaboration	4
8/14/2023	Municipal	MSA & State CPRG Working Group	Priority Measures & Engagement	9
9/11/2023	Municipal	MSA & State CPRG Working Group	Priority Measures & Engagement	9
9/21/2023	Environmental Justice	Massachusetts Environmental Justice Council	CPRG Overview & Priority Measures	26
9/29/2023	Policy Advisory	Global Warming Solutions Act Implementation Advisory Committee (GWSA IAC)	Priority Measures	18
9/12/2023	Municipal	CMRPC	Priority Measures & Implementation Grants	3
10/13/2023	Municipal	MAPC	Priority Measures & Implementation Grants	3
10/17/2023	Municipal	SRPEDD	Priority Measures & Implementation Grants	1
10/16/2023	Municipal	MSA & State CPRG Working Group	Priority Measures & Implementation Grants	8
10/31/2023	Policy Advisory	GWSA IAC Electricity Working Group	Power Sector Measures	5
10/31/2023	Policy Advisory	GWSA IAC Buildings Working Group	Building Sector Measures	5

11/1/2023	Labor	Climate/Labor Federal Funds Working Group	Priority Measures	5
11/8/2023	Environmental Justice	Justice 40 Working Group	CPRG measures	20
11/13/2023	Municipal	MSA & State CPRG Working Group	Measures & Collaboration	7
11/14/2023	Municipal	MAPC Municipal Advisory Committee	CPRG Coordination & Implementation Grants	30
11/15/2023	Environmental Justice	Environmental Justice Stakeholder Meeting	Energy Burden of Electrification Measures	2
11/15/2023	Municipal	West Brookfield Town Hall (CMRPC)	Regional Priorities for Measures	30
11/16/2023	Municipal	Berkshire Regional Planning Commission	Regional Priorities for Measures	12
11/20/2023	Municipal	MAPC Municipal Advisory Committee	Regional Priorities for Measures	30
11/20/2023	Municipal	MAPC & City of Boston	Coordination & Collaboration	2
11/22/2023	Municipal	MAPC	Measures & PCAP Content	3
11/27/2023	Municipal	MSA & State CPRG Working Group	Measures & Collaboration	7
11/29/2023	Policy Advisory	IAC Transportation Working Group	Transportation Sector Measures	4
12/1/2023	Municipal	Massachusetts Regional Planning Agencies	Priority Measures & Equity Priorities	10
12/6/2023	Labor	Climate/Labor Federal Funds Working Group	PCAP Measures, Schools, & Equity	5
12/6/2023	Municipal	Boston City	School Decarbonization	2
12/8/2023	Policy Advisory	IAC Work Group Leads	Committee Engagement	4
12/11/2023	Municipal	MSA & State CPRG Work Group	Methodology for CPRG Analyses; Aligning State & Regional Plans	7
12/11/2023	Municipal	City of Melrose	School Decarbonization	1
12/12/2023	Environmental Justice	Justice 40 Working Group	Measures, Equity Priorities, Survey Input	30

12/14/2024	Municipal	Massachusetts Regional Planning Agencies	Priority Measures & Equity Priorities	10
12/14/2023	Policy Advisory	Global Warming Solutions Act Implementation Advisory Committee (GWSA IAC)	CPRG updates: Priority measures, Survey Results	18
12/18/2023	Municipal	MA Gateway Cities; MassInc	PCAP Content, Implementation Grant Process	68
12/20/2023	Municipal	SRPEDD Municipal Advisory Group	Regional Priority Measures	15
12/21/2023	Environmental Justice	Wampanoag Tribe of Gay Head	CPRG Process & Collaboration	1
1/5/2024	Labor	Policy Group on Tradeswomen Issues	Workforce Equity Actions for PCAP Measures	5
1/8/2024	Municipal	MSA & State CPRG Working Group	Community Engagement; State & MSA Grant Coordination	8
1/9/2024	Municipal	MAPC Municipal Advisory Group	Prioritization & Evaluation of Regional Measures	30
1/10/2024	Municipal	Pioneer Valley Planning Commission (PVPC)	Reginal Priorities for CPRG; Regional Decarbonization Challenges	40
1/22/2024	Municipal	MSA & State CPRG Working Group	Implementation Grants, Measures Coordination	7
1/26/2024	Municipal	SRPEDD Municipal Advisory Group, Meeting #2	Regional Priorities for Measures	15
2/1/2024	All	CPRG Community Meeting #1	PCAP Content & Implementation Grants	26
2/2/2024	All	CPRG Community Meeting #2	PCAP Content & Implementation Grants	71
2/6/2024	Municipal	SRPEDD Municipal Advisory Group, Meeting #3	Prioritization of Regional Measures	15
2/7/2024	Labor	Climate/Labor Federal Funds Working Group	PCAP Content & Federal Funding Opportunities	5

2/8/2024	Environmental Justice	Massachusetts Environmental Justice Council	PCAP Content & Implementation Grants	29
2/15/2024	Environmental Justice	Justice 40 Working Group	PCAP Content & Implementation Grants	40

Appendix N: Co-Pollutants

The tables below provide a full breakdown of the co-pollutant emissions breakdown by county and sector.

Baseline detailed summary

2020 Massachusetts Criteria Pollutant and HAP Emissions Inventory by PCAP Sector, County, and Pollutant

TRANSPORTATION					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	2,675	258	13	2,538	767
MA - Berkshire	846	564	3	1,075	329
MA - Bristol	2,800	338	16	2,146	613
MA - Dukes	628	55	2	527	160
MA - Essex	4,908	505	26	3,793	1,099
MA - Franklin	798	767	3	1,117	349
MA - Hampden	2,692	515	12	1,688	483
MA - Hampshire	727	432	4	665	192
MA - Middlesex	7,705	1,023	45	6,071	1,794
MA - Nantucket	344	29	1	361	109
MA - Norfolk	3,446	443	22	2,615	779
MA - Plymouth	2,685	335	15	2,653	794
MA - Suffolk	3,757	333	27	1,924	572
MA - Worcester	5,084	1,205	24	3,458	1,000
Sector Total	**39,097**	**6,802**	**213**	**30,630**	**9,039**

COMMERCIAL AND RESIDENTIAL BUILDINGS					
MA County	NOx (tons)	$PM_{2.5}$ (tons)	SO_2 (tons)	VOC (tons)	HAP (tons)
MA - Barnstable	527	595	13	1,453	278
MA - Berkshire	337	572	16	1,289	277
MA - Bristol	1,224	1,026	25	3,712	610
MA - Dukes	42	71	2	150	32
MA - Essex	1,589	1,083	25	4,699	727
MA - Franklin	164	335	9	717	162
MA - Hampden	1,081	1,062	40	3,604	633
MA - Hampshire	328	510	13	1250	255
MA - Middlesex	3871	2,412	63	9,663	1,488
MA - Nantucket	26	46	1	87	16
MA - Norfolk	1,593	1,204	28	4,277	687
MA - Plymouth	1,122	1,026	25	3,298	570
MA - Suffolk	2,062	823	27	3,889	499
MA - Worcester	1,766	2,068	55	6,414	1,187
Sector Total	**15,732**	**12833**	**340**	**44504**	**7,423**

ELECTRIC POWER					
MA County	NOx (tons)	$PM_{2.5}$ (tons)	SO_2 (tons)	VOC (tons)	HAP (tons)
MA - Barnstable	30	18	18	5	1
MA - Berkshire	7	1	0	2	1
MA - Bristol	106	23	8	19	7
MA - Dukes	52	2	3	4	0
MA - Essex	39	7	2	2	1
MA - Franklin	7	100	3	13	0
MA - Hampden	185	51	30	49	6
MA - Hampshire	11	17	3	3	0
MA - Middlesex	243	42	5	52	7
MA - Nantucket	0	0	0	0	0
MA - Norfolk	190	55	18	33	4
MA - Plymouth	26	4	2	3	0
MA - Suffolk	223	66	23	14	10
MA - Worcester	204	71	8	23	10
Sector Total	**1,324**	**457**	**122**	**222**	**48**

WASTE & WASTEWATER					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	10	46	3	52	33
MA - Berkshire	39	183	13	132	50
MA - Bristol	61	289	21	193	60
MA - Dukes	3	15	1	10	6
MA - Essex	31	144	10	133	54
MA - Franklin	24	115	7	81	40
MA - Hampden	66	308	24	209	45
MA - Hampshire	47	221	16	148	47
MA - Middlesex	113	528	43	415	115
MA - Nantucket	1	5	0	10	7
MA - Norfolk	3	13	0	64	52
MA - Plymouth	47	221	16	144	50
MA - Suffolk	0	1	0	46	9
MA - Worcester	195	913	69	591	149
Sector Total	**639**	**3,002**	**224**	**2,228**	**719**

INDUSTRY					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	19	24	0	187	28
MA - Berkshire	17	55	0	208	26
MA - Bristol	87	98	1	838	100
MA - Dukes	2	0	0	13	2
MA - Essex	136	152	1	638	104
MA - Franklin	11	23	0	75	14
MA - Hampden	59	74	0	438	48
MA - Hampshire	11	54	0	121	15
MA - Middlesex	228	557	2	2,744	287
MA - Nantucket	2	2	0	27	3
MA - Norfolk	88	166	1	792	102
MA - Plymouth	54	74	0	587	66
MA - Suffolk	54	254	0	1,090	64
MA - Worcester	114	219	1	886	132
Sector Total	**882**	**1,753**	**6**	**8,646**	**992**

AGRICULTURE					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	2	19	1	50	7
MA - Berkshire	0	43	0	11	5
MA - Bristol	2	28	1	38	7
MA - Dukes	-	5	-	1	0
MA - Essex	1	18	1	17	4
MA - Franklin	0	33	0	8	3
MA - Hampden	5	38	3	70	14
MA - Hampshire	2	45	1	32	7
MA - Middlesex	2	24	1	28	5
MA - Nantucket	-	4	-	1	0
MA - Norfolk	-	5	-	1	0
MA - Plymouth	1	10	1	17	3
MA - Suffolk	-	4	-	0	0
MA - Worcester	7	82	4	113	22
Sector Total	**23**	**357**	**12**	**385**	**78**

NATURAL AND WORKING LANDS					
MA County	**NOx (tons)**	**$PM_{2.5}$ (tons)**	**SO_2 (tons)**	**VOC (tons)**	**HAP (tons)**
MA - Barnstable	51	1	0	3,660	252
MA - Berkshire	80	1	0	7,690	779
MA - Bristol	84	3	0	5,922	394
MA - Dukes	10	0	0	554	58
MA - Essex	84	6	1	6,163	449
MA - Franklin	63	7	1	7,628	735
MA - Hampden	85	15	2	7,717	598
MA - Hampshire	77	3	0	6,811	578
MA - Middlesex	112	8	1	10,548	777
MA - Nantucket	5	-	-	170	29
MA - Norfolk	62	4	0	5,492	364
MA - Plymouth	93	7	1	6,582	484
MA - Suffolk	24	-	-	1,422	107
MA - Worcester	159	17	2	16,905	1,343
Sector Total	**990**	**71**	**7**	**87,264**	**6,946**

Co-Pollutant Analysis Calculation Methodology

T1. Adopt Zero Emission Medium- and Heavy-Duty Vehicles

1. Use Massachusetts Vehicle Census MassVehicleCensus | GeoDOT (arcgis.com) for fossil fuel medium- and heavy-duty vehicle counts:
   a. Total Registered Medium- and Heavy-Duty Vehicles: 160,928
   b. Percent of Medium- and Heavy-Duty Vehicles using Gas: 29%
   c. Percent of Medium- and Heavy-Duty Vehicles using Diesel: 71%
2. The measure assumes 10% of medium- and heavy-duty vehicles electrify
   a. Total number of EVs: 16,093
3. Calculate nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s using the AVERT tool. Due to AVERT tool limitations, the Medium- and Heavy-Duty Vehicles are assumed to be bus. Data in AVERT tool for fuel split of buses is adjusted to represent 29% of vehicles using gas, and 71% using Diesel.
4. The AVERT tool considers both the impact of EVs as compared to fossil fuel vehicles and the impact of added electricity demand. The numbers presented are the NET changes as a result of these two factors. Added capacity from renewable sources was not considered for this measure and are addressed separately in power sector measures.
5. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs.

T2. Adopt Zero Emission Passenger and Light-Duty Vehicles

1. Use Massachusetts Vehicle Census MassVehicleCensus | GeoDOT (arcgis.com) for fossil fuel light-duty vehicle counts, and daily VMT from 1/1/2020.
   a. Light-duty: 3,198,637 vehicles, 82,172,657 daily VMT
   b. Unknown: 1,602,948 vehicles, 40,860,089 daily VMT
2. Unknown vehicles are assumed to be light-duty or passenger vehicles.
3. Using Mass Vehicle Census Data – Advanced Vehicle Type table, assume all Class 1 vehicles are "passenger" and all Class 2 vehicles are "light-duty"
   a. Calculate percent breakdown between passenger and light-duty
   b. Light duty trucks = 19.2%, passenger = 80.8%
4. Apply this percent breakdown to total light-duty and "unknown" vehicles from Mass Vehicle Census
   a. Passenger vehicles = 3,879,703 vehicles, 99,411,025 daily VMT
   b. Light Duty = 921,882 vehicles, 23,621,721 daily VMT
5. Assume 15% of passenger and light-duty vehicles electrify
   a. Total number of EVs: 720,238

6. Calculate nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s using the AVERT tool. The AVERT tool considers both the impact of EVs as compared to fossil fuel vehicles and the impact of added electricity demand. The numbers presented are the NET changes as a result of these two factors. Added capacity from renewable sources was not considered for this measure and are addressed separately in power sector measures.
7. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs

T3 Increase Alternatives to Personal Vehicle Use

1. Use the 2020 Massachusetts Criteria Pollutant and HAP Emissions Inventory by PCAP Sector, County, and Pollutant for the Transportation sector:
   a. NOx (tons): 39,097
   b. $PM_{2.5}$ (tons): 6,802
   c. SO_2 (tons): 213
   d. VOC (tons): 30,630
   e. HAP (tons): 9,039
2. Assume 3% of passenger vehicle emissions reduction by mode-shift to active transit.
3. Apply 3% reduction to baseline co-pollutants assuming active transit does not produce criteria pollutant emissions.
4. Calculate emissions reduction by subtracting reduction measure emissions from baseline.

B1 Increase Building Efficiency

1. Use the calculated electricity emissions savings from the efficiency upgrades to calculate the total electricity saved:
   a. Total Emissions Savings: 1.093 MMTCO2e
   b. Electricity Grid Emissions Factor: 412 lbCO2e/MWh
   c. Total Electricity Savings: 5,850 GWh
2. Using the AVERT tool, estimate the co-pollutants nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s using the total electricity savings as a reduction the annual generation required for buildings due to the added efficiency.
3. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs

B2 Decarbonize building heating systems

1. Baseline co-pollutants for heating of Commercial and Residential buildings was pulled from the NEI Database for Massachusetts. The table below provides a summary of

relevant co-pollutant data used to estimate reductions from decarbonizing building heating systems:

SCC LEVEL 2	SCC LEVEL 3	SCC LEVEL 4	NOx (tons)	PM2.5 (tons)	SO2 (tons)	VOC (tons)	HAP (tons)
Commercial/ Institutional	Distillate Oil	Boilers	124.71	13.28	1.33	2.12	0.98
Commercial/ Institutional	Distillate Oil	IC Engines	771.37	55.55	50.83	53.64	0.81
Commercial/ Institutional	Kerosene	Total: All Combustor Types	7.14	0.75	2.53	0.12	0.01
Commercial/ Institutional	Liquified Petroleum Gas (LPG)	Total: All Combustor Types	246.15	0.69	1.04	8.99	0.12
Commercial/ Institutional	Natural Gas	Total: Boilers and IC Engines	3,765.00	16.19	22.59	207.07	3.07
Commercial/ Institutional	Residual Oil	Total: All Boiler Types	12.94	0.78	18.74	0.27	0.03
Residential	Distillate Oil	Total: All Combustor Types	3,484.12	528.57	0.26	176.94	11.15
Residential	Firelog	Total: All Combustor Types	87.25	322.47	-	449.19	13.81
Residential	Kerosene	Total: All Heater Types	13.93	2.11	-	0.70	0.04
Residential	Liquified Petroleum Gas (LPG)	Total: All Combustor Types	632.87	1.92	2.69	24.64	0.36
Residential	Natural Gas	Total: All Combustor Types	5,655.65	25.87	36.10	330.92	4.68
Residential	Wood	Fireplace: general	118.04	1,071.43	18.16	858.05	348.27
Residential	Wood	Furnace: Indoor, cordwood-fired, non-EPA certified	25.52	391.25	28.78	165.86	67.35
Residential	Wood	Furnace: Indoor, pellet-fired, general	4.37	3.52	0.37	2.53	1.03
Residential	Wood	Hydronic heater: indoor	17.62	563.96	17.89	593.92	241.06
Residential	Wood	Hydronic heater: outdoor	27.59	882.72	28.00	929.62	377.31
Residential	Wood	Hydronic heater: pellet-fired	1.46	1.17	0.12	0.84	0.34
TOTAL			**14,995.72**	**3,882.25**	**229.43**	**3,805.40**	**1,070.42**

2. The following electrification strategies are assumed for this measure:
    a. 10% of housing units electrify space and water heating with heat pumps
    b. 13% of commercial buildings electrify space and water heating with heat pumps
    c. 5% of housing units electrify heating with geothermal heat pumps
    d. 3% of commercial buildings electrify heating with geothermal heat pumps
3. Use the estimated GHG reductions as a proxy for reduced Co-pollutants in the residential and commercial building sectors. The following reduction percentages were used:[61]

[61] Refer to GHG Reduction methodology for calculation of percent reduction in GHG emissions.

a. Residential Building Sector Co-Pollutant Reduction: 8%
b. Commercial Building Sector Co-Pollutant Reduction: 5%

P1 Develop New Renewable Energy Facilities

1. Use "Phased" targets for new renewable energy facilities from 2020 and by 2030 from Massachusetts Clean Energy and Climate Plan for 2025 and 2030
    a. 2020 Onshore wind capacity: 130 MW
    b. 2020 Offshore wind capacity: 0.00 MW
    c. 2020 Solar PV capacity: 3,390 MW
    d. 2030 Onshore wind capacity: 440 MW
    e. 2030 Offshore wind capacity: 3,210 MW
    f. 2030 Solar PV capacity: 8,360 MW
2. Subtract the 2020 baseline renewable energy to get added capacity for the 2030 scenario.
    a. 2030 Onshore wind added capacity: 310 MW
    b. 2030 Offshore wind added capacity: 3,210 MW
    c. 2030 Solar PV added capacity: 4,970 MW
3. Calculate nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s with the AVERT tool using the added capacity for each renewable energy source.
4. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs.

P2 Increase utilization of new generation capacity

1. Assumes the following new generation capacity based on the GHG emissions reduction
    a. Assume baseline emission from electricity generation includes 5.13% transmission losses as reported by EIA for Massachusetts in 2019
    b. Calculate 5.13% of baseline emissions from electricity generation
    c. Assume improvement by 50% from investing in new electric infrastructure improvements
    d. Results in 51.38 GWh of reduced generation due to system efficiency.
2. Develop municipal microgrids measure:
    a. Assume (2) 400 kW microgrid, similar to Chelsea microgrid size
    b. Use NREL's PVWatts for Boston location to estimate annual energy generation from 400 kW solar array
    c. Results in annual production of 524 MWh per year

3. Total GWh from transmission efficiency measure and municipal solid grid will reduce electricity generation requirement from the grid.
4. Calculate nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s with the AVERT tool using total reduced energy generation as a result of each measure.
5. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs.

P3 Increase deployment of building-scale renewables

1. Solar PV:
    a. Assume 4 kW solar on homes, 50 kW solar on commercial buildings
    b. Assume 5% of homes install 4 kW arrays, 10% of commercial buildings install 50 kW arrays
        i. 4 kW solar systems on 15% of homes: 1,137 MW
        ii. 50 kW solar systems on 10% of buildings: 845 MW
2. Distributed wind:
    a. Assume 12 kW turbines at 1% of commercial buildings
        i. Adds 20.28 MW of added capacity
    b. Assume 4 kW turbines at 5% of homes
        i. Adds 379.1 MW of added capacity
3. Calculate nitrogen oxides (NOx), direct fine particulate matter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC)s with the AVERT tool using the added capacity for each renewable energy source.
4. HAP emissions reductions are estimated by assuming the same percent reduction as VOCs.

N1 Implement Nature Based Solutions

Not applicable. No co-pollutant calculations for carbon sequestration.

W1 Reduce Organic Waste Through Composting

1. Baseline co-pollutants from landfills and household waste was pulled from the NEI Database for Massachusetts. The table below provides a summary of relevant co-pollutant data used to estimate reductions from composting:

SCC LEVEL 2	SCC LEVEL 3	SCC LEVEL 4	NOx (tons)	PM2.5 (tons)	SO2 (tons)	VOC (tons)	HAP (tons)
Landfills	Municipal	Total	-	-	-	582.09	472.77
Open Burning	Residential	Household Waste	-	-	-	-	-
TOTAL			**-**	**-**	**-**	**582.09**	**472.77**

2. The following electrification strategies are assumed for this measure:
    a. Assume 10% adoption; 10% of food waste diverted from landfills to compost facilities
3. Use the estimated GHG reductions as a proxy for reduced Co-pollutants from. The following reduction percentages were used:[62]
    a. Co-Pollutant Reduction from Composting: 14%

[62] Refer to GHG Reduction methodology for calculation of percent reduction in GHG emissions.