Massachusetts Clean Energy and Climate Plan for 2025 and 2030

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Executive Office of Energy and Environmental Affairs

Massachusetts Global Warming Solutions

Front Cover: Photo taken by Nicole Cooper of Quinsigamond River at Ekblaw Landing in Grafton, Massachusetts.

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LETTER FROM THE SECRETARY

I am pleased to present the Massachusetts Clean Energy and Climate Plan for 2025 and 2030 ("2025/2030 CECP" or "Plan"), as required by the Global Warming Solutions Act of 2008 and the 2021 Climate Law (An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy). The Commonwealth is at the forefront of climate action—combating climate change through strategic planning and thoughtful policy development. The Baker-Polito Administration has taken an ambitious approach to reducing the release of harmful greenhouse gas emissions into the atmosphere, and this 2025/2030 CECP will further these efforts and maximize our ability to achieve net zero in 2050.

The 2025/2030 CECP includes Massachusetts' roadmap to realize economy-wide emissions limits and sector-specific sublimits in 2025 and 2030. This comprehensive planning document outlines specific strategies, policies, and implementation goals and benchmarks for the Commonwealth to reduce emissions in a cost-effective and equitable manner. Implementation of the wide-ranging policies and actions in this Plan will help the Commonwealth procure renewable and clean energy resources, decarbonize and electrify our transportation system and building stock, and expand the conservation and restoration of our natural and working lands, all while reducing negative impacts and increasing investments in environmental justice communities. Importantly, the 2025/2030 CECP provides a pathway for the Commonwealth to meet its emissions limits while ensuring a thriving and just economic transition for everyone.

Specifically, the Plan prioritizes actions within several sectors of the economy to close the gap between current emissions and future emissions targets. These initiatives include the implementation of the California vehicle emissions standards to advance the electrification of cars and trucks; increasing electric vehicle charging infrastructure while expanding investments in the public transportation system; pursuing recommendations from the Commission on Clean Heat to transform how homes and businesses are heated; doubling the state's efforts to conserve natural and working lands; and significantly expanding tree planting, especially in environmental justice neighborhoods.

Additionally, the Plan aligns with the Baker-Polito Administration's efforts to foster, support, and invest in the clean energy industry, which is anchored by offshore wind generation. The industry will experience tremendous growth over the next several years with at least 3,200 megawatts of offshore wind expected to be in operation by 2030. The 2025/2030 CECP highlights increased investments in this sector that will better position the Commonwealth to capitalize on this growth, especially through the creation of a local, qualified workforce to sustain the new low-carbon economy.

We look forward to working with stakeholders, advocates, lawmakers, and industry experts as we collectively implement the policies and programs in this Clean Energy and Climate Plan for 2025 and 2030, which will be a tremendous guiding resource for years to come.

Sincerely,

BETHANY A. CARD

Secretary of Energy and Environmental Affairs

ACKNOWLEDGEMENTS

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Charlie Baker, Governor
Karyn Polito, Lieutenant Governor
Bethany A. Card, Secretary of Energy and Environmental Affairs
Kathleen Theoharides, former Secretary of Energy and Environmental Affairs
Judy Chang, Undersecretary of Energy and Climate Solutions

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EXPLANATION OF TERMS AND ACRONYMS

ACT4All	Accelerating Clean Transportation for All, a program by the Massachusetts Clean Energy Center
AIM Act	American Innovation and Manufacturing Act, signed into U.S. law in 2020
Anaerobic Digesters	Sealed tanks that allow microorganisms to break down sewage and organic waste without using oxygen. The process emits methane gas that are captured and burned to create electricity.
APS	Alternative Energy Portfolio Standard
ARPA	American Rescue Plan Act, signed into U.S. law in 2021
BEV	Battery Electric Vehicles
BOEM	U.S. Bureau of Ocean and Energy Management
CARB	California Air Resources Board
Carbon Sequestration	The removal and storage of carbon dioxide from the atmosphere, commonly by plants and soil.
CECP	Clean Energy and Climate Plan
CES	Clean Energy Standard
CES-E	CES for existing resources
CO_2	Carbon Dioxide
DCR	Massachusetts Department of Conservation and Recreation
DERs	Distributed Energy Resources
DFG	Massachusetts Department of Fish and Game
DOER	Massachusetts Department of Energy Resources
DPU	Massachusetts Department of Public Utilities
E-bike	Electric bicycle
EDCs	Electric Distribution Companies
EEA	Massachusetts Executive Office of Energy and Environmental Affairs
EEAC	Energy Efficiency Advisory Council
EFSB	Energy Facilities Siting Board
EIA	U.S. Energy Information Administration
EJ	Environmental Justice
Emissions Limits	The level at which greenhouse gas emissions in Massachusetts cannot exceed.

Emissions Sublimits	The level at which greenhouse gas emissions from a specific sector cannot exceed.
EOHED	Massachusetts Executive Office of Housing and Economic Development
EPA	U.S. Environmental Protection Agency
EVs	Electric Vehicles
FCEM	Forward Clean Energy Market
F-Gas	Fluorinated Gas – Greenhouse gas that have fluorine, such as different types of hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF_6).
GHG	Greenhouse Gas – Greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), different types of hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6), trap heat and cause the average global air temperature to rise, thus changing weather patterns globally.
GHG Inventory	Greenhouse Gas Inventory – A list of emission sources and their annual emissions quantified using standardized methods.
Ground-Mount Solar	Solar panels that are set up on the ground to capture energy from the sun to create electricity. Rooftop solar is solar panels that are installed on top of buildings.
GSEPs	Gas System Enhancement Plans
GW	Gigawatt
GWh	Gigawatt hours – Unit of energy that is equivalent to one million kilowatt hours, and often used as a measure of the output of large electricity power stations
GWP	Global Warming Potential
GWSA	Global Warming Solutions Act, signed into law in Massachusetts in 2008
HFC	Hydrofluorocarbon
HVAC	Air Conditioning System
IAC	Implementation Advisory Committee
IEOs	Initial Employment Outputs
IIJA	Infrastructure Investment and Jobs Act, signed into U.S. law in 2021
IMPLAN	Impact Analysis for Planning
IPCC	Intergovernmental Panel on Climate Change
ISO-New England	Independent System Operator-New England
LAP	Language Access Plans
MassCEC	Massachusetts Clean Energy Center

MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transportation Authority
MDAR	Massachusetts Department of Agricultural Resources
MEPA	Massachusetts Environmental Policy Act
$MMTCO_2e$	Million metric tons of carbon dioxide equivalent – This is a measure of how much greenhouse gas is emitted into our atmosphere. An emission of 1 $MMTCO_2e$ is equivalent to burning 112,523,911 gallons of gasoline.
MSW	Municipal Solid Waste
MLP	Municipal Light Plant
MW	Megawatts
MWC	Municipal Waste Combustors – Also known as incinerators or waste-to-energy plants.
NECEC	New England Clean Energy Connect
NESCOE	New England States Committee on Electricity
NWL	Natural and working lands as defined in Chapter 8 of the Acts of 2021.
PIP	Public Involvement Plans
PM	Particulate Matter
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Energy Portfolio Standard
SEOs	Secondary Employment Outputs
SF_6	Sulfur Hexafluoride
SMART	Solar Massachusetts Renewable Target
Stretch building or energy code	Standards for energy usage in buildings and tightness of the building shell for which newly constructed buildings must meet.
SWMP	Solid Waste Master Plan: Working Together Toward Zero Waste
TAA	Trade Adjustment Assistance
TWH	Terawatt Hour
VMT	Vehicle Miles Travelled
WWTPs	Wastewater Treatment Plants
ZEV	Zero Emission Vehicle, which includes battery electric vehicle (BEV) and hydrogen fuel cell vehicle (HFCV)

EXECUTIVE SUMMARY

In 2021, Governor Charlie Baker signed into law An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, which amends the Global Warming Solutions Act of 2008 and requires the Secretary of Energy and Environmental Affairs to set limits on greenhouse gas (GHG) emissions for 2025 and 2030, including both economy-wide emissions reduction requirements and specific limits on major sources of global warming pollution. These statutory limits must be accompanied by a comprehensive plan to achieve the required emissions reductions. As part of a letter issued contemporaneously with the Clean Energy and Climate Plan for 2025 and 2030 (2025/2030 CECP), the Secretary of the Executive Office of Energy and Environmental Affairs has determined that the Commonwealth's economy-wide emissions limit will be a 33% reduction from 1990 level in 2025, and a 50% reduction in 2030.

This 2025/2030 CECP represents the Baker-Polito Administration's comprehensive plan to achieve the Commonwealth's emissions reduction requirements. It builds on the Administration's progress setting nation-leading goals for energy efficiency and clean energy and making game changing investments in new technologies such as offshore wind. The Plan expresses the state's collective vision for a 2050 future in which there is minimal reliance on fossil fuels for heating homes, powering vehicles, and operating the electric grid. This Plan reflects confidence that Massachusetts can help lead the clean energy transition and that doing so will mean more well-paying jobs, improved public health, reduced consumer costs, and better quality of life for all residents.

This 2025/2030 CECP includes a portfolio of strategies and policies designed to achieve sector-specific GHG emissions sublimits, including for transportation, buildings, electricity generation, industrial emissions, and non-energy emission sources such as leaks of natural gas and refrigerants. Recognizing the important role that carbon sequestration will play in achieving net-zero emissions, the Plan also includes goals and actions to reduce GHG emissions and increase carbon sequestration on natural and working lands (NWL).

Economic analysis conducted as part of this 2025/2030 CECP estimates that the strategies and policies designed to achieve our emissions limits and sublimits will help grow the Massachusetts economy. Overall modeling indicates that the 2025/2030 CECP will result in a net gain of over 22,000 jobs by 2030, most of which will be in installing electric vehicle chargers, solar photovoltaic projects, energy efficiency retrofits in buildings, offshore wind projects, and transmission lines to connect the clean energy that powers the economy. Ninety-five percent of new jobs will be middle to high wage, paying over $26 per hour. Reduced consumer spending on imported oil and gas will lead to an average household savings of approximately $400 per year, making the local economy more resilient to swings in global fossil fuel prices. Improved air quality will result in public health benefits valued at over $400 million per year.

Ensuring that the economic and environmental benefits of the transition to clean energy works for all Massachusetts residents will require focused attention to support individuals and families with modest incomes and those located in heavily impacted environmental justice communities. Every policy designed to achieve the GHG emissions reduction targets has been developed with a lens that focuses on delivering positive outcomes for environmental justice populations.

Figure ES.1. Historical and Modeled GHG Emissions and Statutorily Required Emissions Reduction

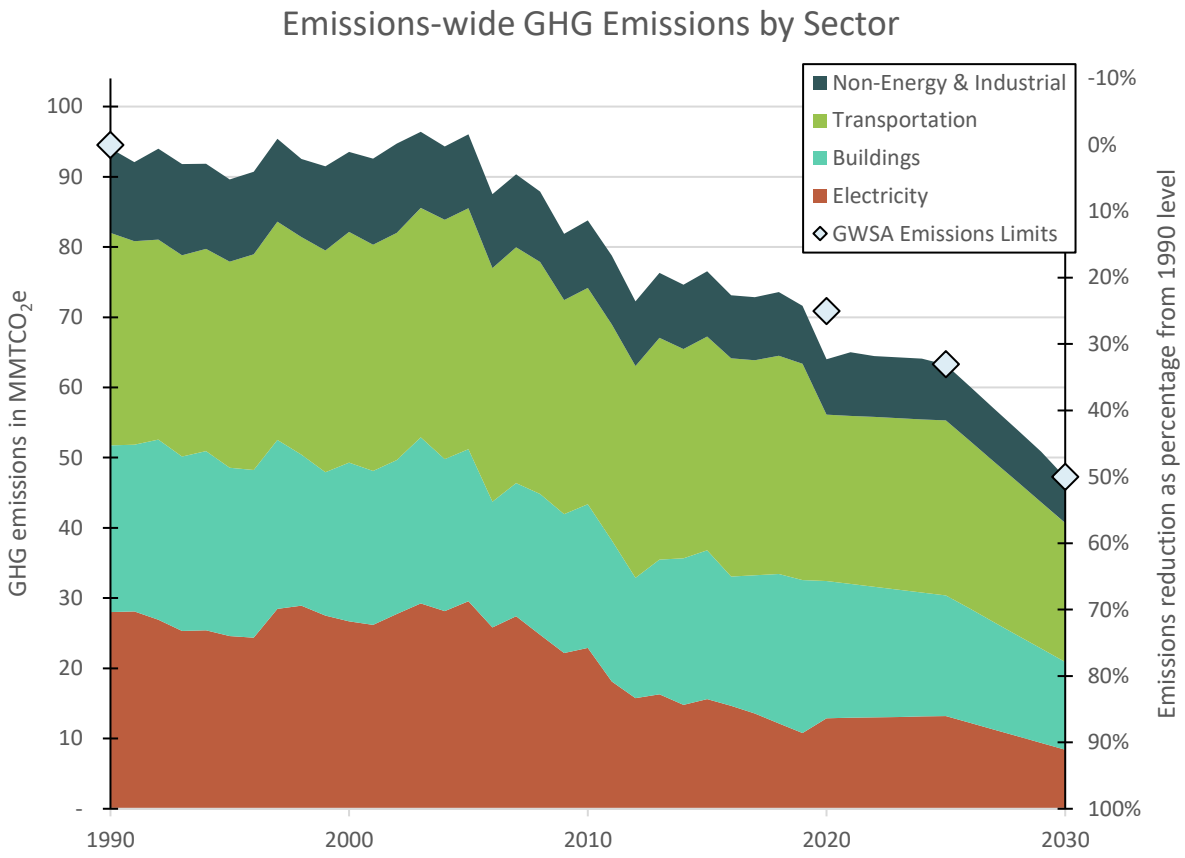


Figure ES.1 above shows the historical GHG emissions in Massachusetts, by four major sectors of the economy: electricity, buildings, transportation, and non-energy and industrial sectors. This figure shows (a) that Massachusetts has met its 2020 economy-wide GHG emissions requirement of 25% reduction from 1990 level and (b) the GHG emissions reduction limits set by this Plan for 2025 is 33% reduction from 1990 level, with the statutorily required 2030 GHG emissions limit at 50% reduction from 1990 level.

Transportation is the largest source of GHG emissions in the Commonwealth, responsible for 37% of statewide emissions in 2020. Pollution in the transportation sector is caused by the combustion of fossil fuels in the engines of cars, trucks, airplanes, and other vehicles. The 2025/2030 CECP presents primary strategies to reduce pollution from the transportation sector including: (1) reducing growth in total vehicle miles travelled (VMT) by improving alternatives to personal vehicles and (2) transitioning most vehicles on the road to electric vehicles. Table ES.1 shows that the sector-specific GHG emissions sublimit for Transportation is set at 18% and 34% reduction from the 1990 level in 2025 and 2030, respectively.

Massachusetts' plan to reduce VMT growth builds on some of the critical programs that have been enacted by the Baker-Polito Administration to improve public transportation, build more housing and redesign our public space. Massachusetts will work to improve and electrify bus service through the

Massachusetts Bay Transportation Authority (MBTA) Bus Modernization program, encourage transit-oriented development through the MBTA Communities program, invest in active transportation through programs such as Complete and Shared Streets, work with employers to reduce unnecessary travel, and seek to launch a new program to incentivize e-bike purchases.

The Commonwealth will achieve increases in electric vehicle sales through the implementation of vehicle emissions standards that will require all passenger vehicle sales and most medium- and heavy-duty vehicle sales to be electric by 2035. Massachusetts will support consumers by exploring convenient, point of sale rebates for electric vehicle purchases and by investing in charging infrastructure. The state's electric vehicle plan will promote equity by creating a targeted incentive for low-to-moderate-income residents and by prioritizing electrification of fleets with significant public health benefits, such as school buses, delivery trucks, and vehicles for hire.

Table ES.1. Historical and Modeled GHG Emissions and Statutorily Required Emissions Reduction

Transportation	1990	2010	2015	2020	2025	2030
GHG Emissions ($MMTCO_2e$)	30.2	30.8	30.4	23.7	24.9	19.8
Percent Reduction (Increase) from 1990		(2%)	(1%)	22%	18%	34%

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

Heating in buildings by oil and gas represented 30% of statewide GHG emissions in 2020. The Commonwealth's primary strategies to reduce emissions from buildings are to improve the energy efficiency of buildings and convert the heating systems for homes and businesses to electric heat pumps. The Commission on Clean Heat, designed to advise the Governor on how to best reduce emissions from building heating is currently considering different strategies to implement limits on GHG emissions from buildings, including an emissions cap and a uniform method to measure and report building energy use and associated GHG emissions. Massachusetts is working to implement building codes and municipal opt-in net zero energy codes that will require high performance standards for new construction. For existing buildings, Massachusetts will expand incentives available through Mass Save® and provide financing assistance for heat pump installations. One of the core challenges is achieving rapid adoption of electric heat pumps at the scale necessary to decarbonize over two million individual buildings in Massachusetts. The Commonwealth will meet these challenges by advancing efforts in encouraging and creating incentives for building owners to convert existing fossil fuel-based heating systems to electric, training the workforce to install and maintain new technologies, and providing adequate information about the technologies available, their costs, and their value to home and business owners. Table ES.2 below shows the historical actual GHG emissions from residential and commercial heating and the 2025 and 2030 GHG emissions sublimits for residential and commercial building heat. As shown, the 2025 GHG emissions sublimits for residential and commercial building heat are set at 28% reduction in 2025 and 47% reduction in 2030, relative to 1990 level.

Table ES.2. Historical GHG Emissions and 2025/2030 GHG Emissions Sublimits for Residential and Commercial Building Heat

Buildings (Residential & Commercial) Sector GHG Emissions (MMTCO2e)	1990	2010	2015	2020	2025	2030
Residential	15.3	13.7	13.6	12.2	10.8	7.8
Commercial (without Industrial)	8.4	6.7	7.6	7.3	6.4	4.7
Total Gross Emissions ($MMTCO_2e$)	**23.8**	**20.4**	**21.2**	**19.5**	**17.2**	**12.5**
Total Percent Reduction from 1990		**14%**	**11%**	**18%**	**28%**	**47%**

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

Electric power emissions represented approximately 20% of statewide GHG emissions in 2020, primarily from the combustion of natural gas in power plants. Massachusetts has achieved significant reductions in electricity emissions since 1990 through the increase of energy efficiency, retirement of coal power plants, and growth of renewable energy resources including wind and solar. Achieving Massachusetts' emissions limits will require the electricity sector to continue to decarbonize while serving additional demand from the electrification of heating and transportation.

Investments in offshore wind, combined with imports of Canadian hydro and a rapidly growing solar and storage industry in Massachusetts, will put the state on the path to a decarbonized electricity grid. In addition, Massachusetts will continue to cap the emissions from power plants both through the Regional Greenhouse Gas Initiative and in-state rules, while increasing the required clean energy resources to be delivered to Commonwealth residents. The geographic diversity of clean energy available to New England will require the construction of new transmission and distribution infrastructure to connect the new hydroelectric, wind, and solar resources. Careful planning, including public outreach, will be necessary to minimize the environmental impact associated with such infrastructure investments and to mitigate any potential burdens on communities, particularly those with environmental justice populations. Working with other New England states and the regional electricity system operator on redesigning the wholesale electricity market and transmission planning processes will be essential parts of a successful implementation of a clean energy future. Table ES.3 below shows the historical GHG emissions and the 2025 and 2030 GHG emissions limit from the electricity sector. These GHG emissions include those associated with the use of electricity to heat and cool buildings in Massachusetts. The 2025 GHG emissions limit for the electricity sector is set at 53% and the 2030 limit is set at 70% relative to the 1990 level.

Table ES.3. Historical GHG Emissions and 2025/2030 GHG Emissions Sublimits for Electric Power Sector

Electric Power	1990	2010	2015	2020	2025	2030
Gross Emissions ($MMTCO_2e$)	28.0	22.9	15.6	12.9	**13.2**	**8.4**
Percent Reduction (Increase) from 1990		18%	44%	54%	53%	70%

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

GHG emissions from industrial and non-energy sources in Massachusetts come from GHG leaks from refrigeration systems, gas-insulated switchgears, and natural gas infrastructure; solid waste management systems that include landfills and municipal waste combustion; and agricultural processes. The use and leakage of hydrofluorocarbon (HFC) gases in refrigeration have been a growing source of

emissions in Massachusetts. In December 2020, the Baker-Polito Administration promulgated regulations prohibiting the use of HFCs in a broad range of existing end uses. Going forward, federal and potentially additional state regulations will help reduce the use of HFCs in a broader range of equipment, such as heat pumps. In addition, Massachusetts will explore additional ways to reduce leakage of sulfur hexafluoride from electric transmission equipment and gas leaks from our natural gas distribution infrastructure. The Massachusetts Department of Environmental Protection will implement tighter standards on municipal waste combustors, while the solid waste master plan significantly decreases solid waste disposal in the Commonwealth. Table ES.4 shows the historical GHG emissions from industrial and non-energy sectors. It also shows the 2025 and 2030 GHG emissions limits, set collectively at 34% in 2025 and 48% in 2030, relative to the 1990 level.

Table ES.4. Historical GHG Emissions and 2025/2030 GHG Emissions Sublimits for Industrial and Non-Energy Sectors

Industrial and Non-Energy GHG Emissions ($MMTCO_2e$)	1990	2010	2015	2020	2025	2030
Industrial Energy Use	5.8	3.8	3.5	3.2	**2.9**	**2.5**
Natural Gas Distribution & Services	2.3	0.9	0.5	0.6	**0.4**	**0.4**
Industrial Processes	0.7	3.7	4.1	3.1	**3.6**	**2.5**
Agriculture & Waste	3.4	1.2	1.1	1.0	**1.0**	**0.9**
Total Gross Emissions	**12.1**	**9.6**	**9.3**	**7.9**	**7.9**	**6.3**
Total Percent Reduction from 1990		**20%**	**23%**	**34%**	**34%**	**48%**

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

Natural and working lands' ability to sequester emissions will be a critical component of achieving net-zero GHG emissions in Massachusetts. For the first time, this 2025/2030 CECP provides an analysis of the emissions from, and the carbon sequestration by, Massachusetts' NWL; outlines policies to support the conservation, climate smart management, and restoration of NWL; and identifies additional ongoing and existing actions the Commonwealth is pursuing to achieve net zero emissions by 2050.

To protect the Commonwealth's natural resources for carbon sequestration and other benefits, Massachusetts will increase the state's efforts to permanently conserve at least 28% and 30% of undeveloped land and water by 2025 and 2030, respectively. In addition to conservation, the Commonwealth will reduce GHG emissions from NWL and enhance their carbon sequestration capacity through better management and expanded restoration, building upon the Administration's expansion of the Greening the Gateway Cities urban tree planting program. This includes goals to incentivize at least 20% of privately owned forests and farms to adopt climate smart management practices while planting at least 5,000 acres of new urban and riparian trees by 2025 and 16,000 by 2030. Overall, Massachusetts aims to achieve net GHG emissions reduction of 25% below 1990 level in 2030 on natural and working lands.

Table ES.5. Historical and 2025 and 2030 Goals for Net GHG Emissions from Natural and Working Lands

Natural and Working Lands	1990	2010	2015	2020	2025	2030
Net NWL Emissions ($MMTCO_2e$)	-5.9	-6.8	-7.0	-7.0*	**-7.0**	**-7.4**
Goal: Percent Reduction (Increase) from 1990	-	15%	19%	19%*	19%	25%

* Estimated from 2019 data, as data for 2020 are not yet available

Note: Net emissions from inland wetlands not yet accounted for.

CHAPTER 1: INTRODUCTION

Massachusetts' signature climate law, the Global Warming Solutions Act (GWSA),[1] as amended by An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy (2021 Climate Law),[2] requires the Secretary of the Executive Office of Energy and the Environment (Secretary) to adopt statewide greenhouse gas (GHG) emissions limits and sector-specific sublimits. These limits must be accompanied by a comprehensive, clear, and specific roadmap plan to achieve the established limits and sublimits.

By letter issued contemporaneously with this 2025 and 2030 Clean Energy and Climate Plan ("2025/2030 CECP" or "Plan"), the Secretary adopted statewide limits of 33% below 1990 level in 2025 and 50% below 1990 level in 2030. The Secretary also established sector-based sublimits as components of each 2025 and 2030 limit for the electric power, transportation, commercial and industrial heating and cooling, residential heating and cooling, industrial processes, and natural gas distribution and service sectors. The Commonwealth's plans to achieve both its 2025 and 2030 targets rely on many of the same policies and programs; therefore, this 2025/2030 CECP reflects the comprehensive strategies to achieve the statewide GHG emissions limits and sector-specific sublimits adopted by the Secretary for 2025 and 2030.

Massachusetts' approach to achieving its emissions limits and sublimits is based on three basic principles: (1) electrify non-electric energy uses, (2) decarbonize the electric grid, and (3) reduce energy costs and the costs of transition by increasing the efficiency of transportation and energy systems. These principles must be pursued in parallel, as one will not achieve the emissions limits and sublimits without the others.

This Plan includes policies that the state must pursue to achieve the necessary reductions in emissions from transportation, heating and cooling buildings, the electric power, and industrial and non-energy uses. The key considerations when developing each of the policies in this Plan included: GHG emissions reductions, consumer costs and benefits, energy supply and delivery, environmental justice (EJ) and equity, stakeholder input, market transformation, and implementation feasibility. This Plan also sets a benchmark and goals to increase net carbon sequestration from natural and working lands; includes the results of the employment and macroeconomic analysis, which was commissioned to model the impact of our climate policies on key economic indicators, such as jobs and household energy costs; and incorporates strategies to promote equity and reduce emissions in overburdened EJ communities. To track the Commonwealth's progress in achieving the 2025 and 2030 limits and sublimits, this Plan sets numerical benchmarks for adoption of emissions reduction solutions, such as electric vehicles (EVs) and heat pumps, and improvements that will be critical to reduce emissions.

The 2030 Clean Energy and Climate Plan was first released for public comment in December 2020 as an interim plan (Interim 2030 CECP), prior to the enactment of the 2021 Climate Law. This 2025/2030 CECP provides the plan for 2025 and updates the previous Interim 2030 CECP. This Plan builds on years of modeling and analysis on all aspects of our decarbonization strategies, including the previous Clean Energy and Climate Plans and the 2050 Decarbonization Roadmap Study. It reflects the input of

[1] Chapter 298 of the Acts of 2008.
[2] Chapter 8 of the Acts of 2021.

stakeholders, including members of the GWSA Implementation Advisory Committee and its work groups, the Zero-Emission Vehicle Commission, the Clean Heat Commission, the technical advisors to the Natural and Working Lands GHG emissions accounting, as well as thousands of individuals who submitted comments or attended public meetings and hearings over the past three years.

This 2025/2030 CECP is organized as follows:

- Chapter 1 provides background on the GWSA and outlines the guiding principles for the policies and programs that the Commonwealth needs to implement to achieve the 2025 and 2030 limits and accompanying sublimits.
- Chapter 2 explains the core EJ principles that are incorporated throughout the policies recommended in this Plan.
- Chapter 3 outlines the analytical approach used to inform these policies.
- Chapters 4 through 8 details plans to achieve reductions in the following areas:
- Transportation
- Buildings
- Electricity Supply
- Industrial Processes, Gas Distribution, and Non-Energy
- Natural and Working Lands
- Chapter 9 presents the estimated employment and macroeconomic impact of the policies set in this plan.
- Appendices A through F are included as support of the analyses and policies included in this Plan.

1.1 BACKGROUND ON GLOBAL WARMING SOLUTIONS ACT

With the passage of the GWSA in 2008, the Commonwealth of Massachusetts became one of the first states in the nation to move forward with a comprehensive program to address climate change consistent with the mid-century goals established by the Intergovernmental Panel on Climate Change (IPCC). The GWSA sets out a series of requirements and authorities regarding the Commonwealth's achievement of GHG emissions reductions, including the requirement that the Secretary establish a statewide limit for 2050 that is at least 80% below the 1990 baseline emissions level and interim limits for 2020, 2030, and 2040. In 2009, the Secretary adopted the 2020 GHG emissions limit of 25% below the 1990 level.

In the fourteen years since the passage of the GWSA, Massachusetts has made significant progress in many areas, including the decommissioning of its last coal-fired power plant in 2017. Working with regional partners in the Northeast, Massachusetts established the Regional Greenhouse Gas Initiative (RGGI), one of the first market-based programs to reduce emissions from electricity generation. Thanks to programs like Mass Save®, Massachusetts consistently ranks among the most energy-efficient states in the country, saving consumers millions on their energy bills. Under the Baker-Polito Administration,

Massachusetts has procured over 1,600 megawatts (MW) of offshore wind and selected another 1,600 MW for upcoming contract approval, setting up Massachusetts to be a national leader in the clean energy transition.

Picture 1. Governor Baker at Vineyard Wind Event

On June 30, 2022, the Secretary issued a statement indicating that Massachusetts successfully met the 2020 GWSA emissions limit of 25% reduction in emissions below the 1990 level. While the COVID-19 pandemic significantly impacted actual 2020 emissions, the state was on track to achieve the 25% reduction prior to the impact of the pandemic.[3] As detailed in the GWSA 10-Year Progress Report (2018), the Commonwealth has thrived while reducing emissions. The 2021 Massachusetts Clean Energy Industry Report showed continued employment growth within the clean energy sector, reaching 3% of the state's workforce, or 101,000 employees, by the end of 2020. In 2020, the industry contributed over $13.7 billion to Massachusetts' Gross State Product.[4]

The IPCC has estimated[5] that unless there are immediate, large-scale, and rapid reductions in GHG emissions, limiting global warming at or near 1.5 degrees Celsius or even 2 degrees Celsius above pre-industrial levels will be "beyond reach."[6] This 2025/2030 CECP reflects the state's current understanding of the climate crisis and presents the most aggressive decarbonization strateiges put forward by the Commonwealth to date. As the IPCC continues to refine the understanding of climate change, and as Massachusetts continues to build on its knowledge and capabilities, the strategies and policies outlined in this document will continue to evolve in future CECPs and may further accelerate decarbonization in the Commonwealth.

Recognizing the scale and urgency of the climate crisis, in 2020, the Baker-Polito Administration established a 2050 statewide emissions limit of net zero GHG emissions.[7] This net zero requirement was later codified into law by the 2021 Climate Law. A statewide limit of net zero emissions means that in 2050, total GHG emissions emitted by all sources in Massachusetts must be equal to or less than the

[3] Based on pre-COVID-19 analysis conducted in support of the 2018 GWSA 10-Year Progress Report.
[4] 2021 Massachusetts Clean Energy Industry Report, can be found at https://www.masscec.com/2021-massachusetts-clean-energy-industry-report.
[5] The IPCC is the United Nations body for assessing the science related to climate change. The IPCC Assessment Reports are major international climate change reports written by authors from a range of scientific, technical, and socioeconomic disciplines. These reports outline climate change impacts as well as future risks and discuss options for reducing the rate of climate change.
[6] IPCC Press Release 08/09/2021, found at https://www.ipcc.ch/site/assets/uploads/2021/08/IPCC_WGI-AR6-Press-Release_en.pdf
[7] *Determination of Statewide Emissions Limit for 2050* (April 22, 2020). Net zero is defined as 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; provided, however, that in no event shall the level of emissions be greater than a level that is 85 percent below the 1990 level.

total amount of carbon sequestered within Massachusetts or through actions directly attributable to Massachusetts. Net zero emissions also requires that that the level of total emissions shall not exceed 85% below the 1990 level. The policies and actions pursued to achieve the 2025 and 2030 limits must maximize Massachusetts' ability to equitably achieve net zero in 2050.

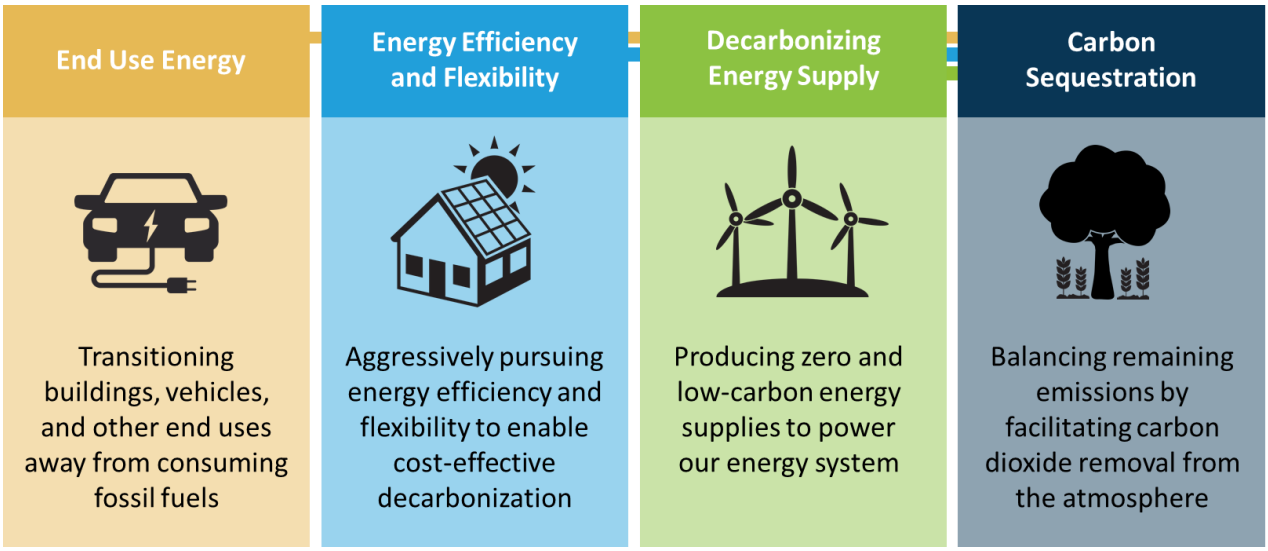
Development Background: 2050 Roadmap Study

To determine the best pathway to achieve the 2050 emissions limit, the Commonwealth engaged in a 2050 Decarbonization Roadmap Study process beginning in 2019. This nation-leading quantitative and qualitative planning effort (henceforth referred to as the "2050 Roadmap Study") developed multiple technical and policy pathways by which the Commonwealth can equitably and cost-effectively achieve net zero in 2050.

The 2050 Roadmap Study scoped eight pathways, each of which analyzes potential annual energy supplies needed to serve projected demand in all sectors of the economy while achieving net zero in 2050. Although the strategies chosen to pursue net zero will impact cost, the analysis showed that the Commonwealth could achieve net zero affordably. The lowest cost, lowest risk pathways share core elements, based upon the four pillars of decarbonization (Figure 1.1). These core elements are common across the pathways and have been appended since the release of the Interim 2030 CECP. The most critical elements to consider when selecting policies and programs to implement over the next eight years include **a balanced clean energy portfolio** anchored by **significant offshore wind resources; widespread electrification of transportation and building heat; cost reductions from pivoting to more efficient technologies at the point of replacement for equipment, infrastructure, and systems that use or deliver fossil fuels;** and **protection, management, and restoration of our natural and working lands** to maintain valuable natural resources that help sequester and store carbon.

The 2050 Roadmap Study found other significant benefits of achieving net zero in 2050, including: a precipitous drop in air pollution, particularly in EJ communities currently over-burdened with poor air quality; significant savings in health costs, up to $100 million per year by 2030; and the creation of thousands of quality local jobs in Massachusetts and across New England.

Figure 1.1. Four Key "Pillars of Decarbonization" to Achieve Net Zero in 2050

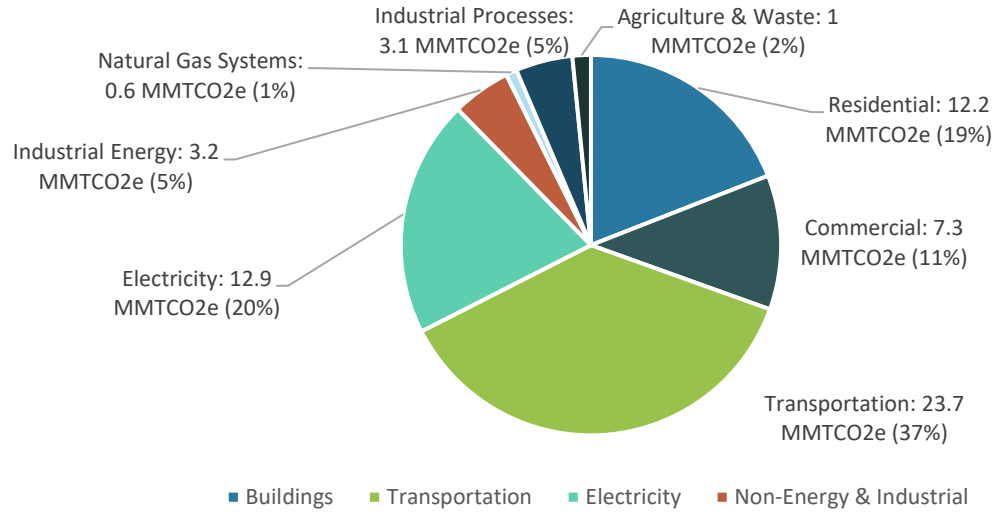


1.2 LOOKING FORWARD TO 2025 AND 2030: ACCELERATING DECARBONIZATION FOR THE COMMONWEALTH

Over the next eight years, the Commonwealth will need to focus on transitioning its transportation and heating systems away from the combustion of fossil fuels. This effort will require incentives and assistance for decision-makers across the Commonwealth to veer away from traditional fossil fuels and toward electrified alternatives in what we drive; how we transport goods; how we design our streets and communities; how we build new buildings and improve existing ones; and how we cool and heat our homes, offices, and other facilities.

Prior to the COVID-19 pandemic, about a quarter of GHG emissions in the Commonwealth came from light-duty vehicles owned and operated by individuals and business owners. Specifically, at the household level, roughly 5 million light-duty passenger cars and trucks generated more than half of all transportation emissions; in 2019, passenger vehicles emitted approximately 17 million metric tons of CO_2-equivalent ($MMTCO_2e$). Similarly, for buildings, Massachusetts has approximately 2.6 million households, whose space and water heating equipment emit between 15% and 20% of the Commonwealth's GHG emissions each year, with significant variance due to weather. Fuels combusted for heat, hot water, and other thermal processes in commercial buildings and industrial facilities account for about 15% of annual emissions, again with variability due to weather. The collective choices that residents make about their next vehicles and heating systems will significantly impact the Commonwealth's ability to achieve the 2025 and 2030 emissions limits and sublimits. Thus, the policies contained in this Plan focus on encouraging and creating incentives for individual decision-makers to move toward a steady and bold reduction of GHG emissions. Figure 1.2 below shows the distribution of the GHG emissions across households, businesses, and other categories.

Figure 1.2. Distribution of Massachusetts GHG Emissions in 2020 (estimate)



Notes: Economy-wide emissions were estimated to be 64.1 MMTCO$_2$e or about 32% below 1990 level. Subtotals shown may not sum to this total due to rounding. The values presented above represent preliminary estimates (as of June 2022) from Massachusetts Department of Environmental Protection (MassDEP) for 2020. These estimates will be updated as new data become available and published in MassDEP's Annual Greenhouse Gas Emissions Inventory.

Existing technologies can replace fossil fuel combustion in both vehicles and in buildings. Electric vehicles are increasingly available in all vehicle classes and can provide superior automotive performance at a lower energy cost. Accelerated and advanced energy efficiency measures in new and existing buildings significantly reduce the energy footprint of buildings. Electric heat pumps designed to heat homes through New England winters and provide cost savings over time are available now and could be adopted by Commonwealth residents. Scaling up these available technologies, in addition to investing in clean energy infrastructure and alternatives to personal vehicle travel, accounts for the majority of the emissions reductions in this Plan.

Electrifying broad sectors of the economy necessarily increases demand for electricity. Successful decarbonization requires the continual reduction of fossil-fuel electricity generation and replacement with renewable and clean energy. Increasing transmission capacity to Massachusetts to carry clean energy into New England's grid, increased development of renewable resources like offshore wind and solar photovoltaics (PV), and equitable enhancements to the distribution network will ensure that all communities in the Commonwealth have sufficient capacity to handle increased electricity demand resulting from electrification.

Local communities play an increasingly important role in the siting of new renewable energy projects and transmission/distribution system upgrades; implementation of zoning and building ordinances that support the development of high-performance, low-carbon emitting buildings and smart growth; significant expansion of the electric vehicle charging network; increased climate adaptation and resiliency; and equitable implementation of policies that impact residents and businesses in their jurisdictions. Thus, the Commonwealth must work closely with all communities to ensure a just and equitable transition.

Picture 2. Roundtable Meeting with U.S. Secretary of Energy at Blade Testing Facility

Federal policies can directly drive market development and contribute to Massachusetts' achievement of its climate goals. Federal actions can signal a strong directional change and inspire the private sector to make long-lasting investments in technology improvement, as well as spur research and development at a greater scale than state policy alone. In addition to the significance of federal policy changes, regional and intrastate developments, such as the RGGI and transmission planning processes in New England, have major impacts on how and how quickly Massachusetts will decarbonize. Due to the impact of federal and interstate policies, the Commonwealth must stay involved in federal and regional policy development. For example, this includes participation in proceedings at the Federal Energy Regulatory Commission regarding the market and transmission planning reforms conducted by the New England grid operator, the Independent System Operator-New England (ISO-New England).

1.3 SETTING GHG EMISSIONS LIMITS, SUBLIMITS, AND PLAN DEVELOPMENT

The Commonwealth developed the economy-wide GHG emissions limits for 2025, the sector-specific GHG emissions sublimits for 2025 and 2030, and the plan to achieve these limits and sublimits through a coordinated process of quantitative and qualitative analyses. This process began by identifying and establishing clear principles: GHG emissions reductions, consumer costs and benefits, energy supply and delivery, equity and environmental justice, stakeholder input, market transformation, and implementation feasibility. Once the goals were defined for how to achieve a clean economy, the Commonwealth developed metrics and conducted analyses to explore different pathways and associated GHG emissions limits that would maximize the state's ability to achieve net zero in 2050. The Commonwealth included stakeholders and consulted with other departments, agencies, and regional authorities to determine the limits and sublimits for 2025 and 2030 and plan for achieving these limits and sublimits. Equity and environmental justice principles were present throughout this process and will remain at the center of implementation of the policies and programs in this Plan.

GENERAL PRINCIPLES

The foundational concept carried throughout this Plan is that it is most cost-effective to replace emitting resources with cleaner technologies at the time of stock-turnover. The policy strategies included in this 2025/2030 CECP were developed to enable the transition to a clean energy economy, ensure environmental justice and equity, consider significant stakeholder input, and ensure practicality and feasibility.

While costs to society and individuals are major considerations across all policies evaluated and selected, attributing individual emissions or cost impacts to each action or policy is difficult. Together, public policies can mobilize and accelerate certain markets, but there are additional market trends that are dependent on drivers outside of Massachusetts' control. Thus, the GHG emissions reductions cannot be separately and precisely attributed to each independent policy or program that the Commonwealth sets. The same is true for cost. For example, the 2050 Roadmap Study shows that deep building envelope efficiency retrofits and electric heat pumps are likely to be the least-cost decarbonization solution across all viable pathways for the economy as a whole. However, the incremental cost for each building will require specific estimates because each building has a unique vintage, renovation history, and needs. Therefore, this 2025/2030 CECP analyzes the GHG emissions reduction costs and impact in terms of policy portfolios, rather than at the level of each individual policy strategy.

To support the policies in this 2025/2030 CECP, the Executive Office of Energy and Environmental Affairs (EEA) has updated the relevant analyses conducted for the 2050 Roadmap Study. Cost and efficiency data for key clean technologies have been updated based on the best available information. The updated analysis focuses on how buildings can be decarbonized over the next eight years, while meeting the statutory requirements. Chapter 3 explains the details of the updated analysis and the GHG emissions limits and sublimits.

As markets evolve around EVs, electric heat pumps, and the retrofitting of existing buildings, the Commonwealth will continue to use the latest information to plan for and achieve 33% emissions reduction in 2025 and 50% by 2030, while maximizing the Commonwealth's ability achieve net zero in 2050 in the most equitable manner.

STAKEHOLDER PROCESS

Stakeholder feedback is critical to construct a clear, comprehensive, and specific plan to achieve the Commonwealth's ambitious GHG emissions limits. This Plan reflects stakeholder feedback and public comments received on the Interim 2030 CECP, multiple stakeholder meetings during policy development, and additional oral and written public feedback received in the Fall of 2021 and Winter/Spring of 2022. Appendix F includes additional information about the stakeholder and public processes informing the development of the 2025/2030 CECP.

In addition to stakeholder and public meetings, EEA consulted with ISO-New England and the GWSA Implementation Advisory Committee (IAC).[8] The IAC has sector-specific working groups on transportation, buildings, electricity, and land use and nature-based solutions. These sector-specific working groups had previously provided recommendations on GHG emissions reduction measures for the Interim 2030 CECP.[9, 10] This 2025/2030 CECP has been developed considering those recommendations.

This Plan incorporates important policies and programs from the Massachusetts Department of Transportation (MassDOT) and the Massachusetts Executive Office of Housing and Economic Development (EOHED) that directly and indirectly affect Massachusetts communities. However, this Plan does not cover many of the on-going transportation, housing, and economic development initiatives that will continue to improve the transportation and housing infrastructure for the Commonwealth.

Stakeholder feedback is important to incorporate at the planning phase and throughout the next eight years as the markets develop and other conditions fluctuate. This 2025/2030 CECP establishes benchmarks for tracking the implementation of the policies and programs to ensure the Commonwealth is on track to achieve the 2025 and 2030 emissions limits and sublimits. In addition to sharing progress with the GWSA IAC, the Secretary will report on the success of each limit within 18 months after the end of each compliance year and include any recommendations to improve the Commonwealth's progress in meeting its targets, as required by the 2021 Climate Law. Building upon the last eight years of data collection for tracking policy implementation, this Plan formalizes key metrics to assess the success of the outlined strategies to achieve the 2025 and 2030 emissions limits and sublimits and maximize the Commonwealth's ability to achieve net zero GHG emissions in 2050.

Starting with the development of the Interim 2030 CECP, EEA has consulted with the following stakeholder groups during the development of the policies within this CECP.

GLOBAL WARMING SOLUTIONS ACT (GWSA) IMPLEMENTATION ADVISORY COMMITTEE (IAC): A total of six meetings were held on April 12, June 28, October 12, and December 10, 2021, and February 28 and April 29, 2022. In addition, IAC working group meetings, including the Buildings Working Group, Transportation Working Group, Climate Justice Working Group, Land Use and Nature-Based Solutions Working Group, and Electricity Working Group, were held on a regular basis to consult on topics related to the Clean Energy and Climate Plan.

[8] The IAC was formed in 2012 to advise on GHG emissions reduction measures, and includes representatives from several sectors, including commercial, industrial, and manufacturing; transportation; low-income consumers; energy generation and distribution; environmental protection; and energy efficiency and renewable energy, as well as from local government and academic institutions.
[9] The IAC recommendations on policies for analysis in the 2050 Roadmap were submitted to EEA on August 22, 2019, and can be accessed at https://www.mass.gov/doc/master-policy-list/download.
[10] The IAC recommendations of policy priorities for the 2030 CECP were submitted to EEA on October 22, 2020, and can be accessed at https://www.mass.gov/doc/iac-work-group-proposed-guiding-principles-and-policy-priorities-updated-10262020/download.

ZERO EMISSION VEHICLE (ZEV) COMMISSION: Four meetings held on February 12, May 5, and July 23, 2021, and April 15, 2022.

ENVIRONMENTAL JUSTICE STAKEHOLDER FOCUS GROUPS: Four sessions held on March 29, April 1, May 25, and May 26, 2021.

COMMISSION ON CLEAN HEAT: Eight meetings held on January 12 and 26, February 9 and 17, March 9 and 23, and April 6 and 27, 2022, in addition to four public webinars held on March 1 and 4, 2022. The Commission will continue to meet regularly until December 2022.

MEPA ADVISORY BOARD: Regular touch points between key staff and stakeholders and EEA.

ENERGY EFFICIENCY ADVISORY COUNCIL (EEAC): Conducted regular touch points with key staff and stakeholders and EEA.

Further, EEA conducted several public hearings and meetings focused on various aspects of this Plan to inform the public of the progress being made and solicit feedback from the public:

INTERIM 2030 CLEAN ENERGY AND CLIMATE PLAN: Two public meetings held on March 9 and 15, 2021.

CLEAN ENERGY AND CLIMATE PLAN FOR 2025 AND 2030:

- Two public hearing held on October 14 and 15, 2021.
- Three public hearings held on April 14 and 15, 2022.

NEW BUILDING CODES: Five public webinars held on March 2, 3, 4, 7, and 8, 2022.

FOREST CARBON GOALS AND POLICIES: Three public webinars held on December 21, 2021, and January 14 and February 11, 2022.

COMMITMENT TO EQUITY

Deep decarbonization will improve air quality for all and bring new economic opportunities that can revitalize cities and towns across the Commonwealth. Thoughtful policies and careful program design are essential to ensure that all Massachusetts residents can fully access and participate in the transition to a low-carbon economy—such as owning an electric vehicle or retrofitting their homes to be more energy efficient. Differences in income-level, location, English proficiency, and previous marginalization must not hinder equitable access to and distribution of benefits of the transition.

The Baker-Polito Administration is committed to ensuring that the policies guiding the transition help reduce the health and economic disparities experienced in EJ communities and communities of color. Chapter 2 of this Plan outlines the Commonwealth's plan for realizing this important commitment, including summarizing results of a macroeconomic impact study that examines the equity outcomes of policy strategies put forth in this document. In addition, Chapter 9 of this Plan describes an employment and macroeconomic analysis and the associated findings.

Participation by EJ populations in the decision-making process and program implementation is beneficial and necessary to meet all emissions limits and sublimits while fulfilling the commitments of the

Commonwealth's Environmental Justice Policy, a central pillar of the Commonwealth's vision for environmental justice. To deliver on this vision, the Commonwealth is committed to enhancing dialogue, stakeholder trust, and governmental transparency.

CHAPTER 2: ENSURING A JUST TRANSITION IN THE COMMONWEALTH

Environmental justice is rooted in the principle that all people deserve protection from environmental pollution and the ability to live in and enjoy a clean and healthy environment, regardless of race, color, income, class, handicap, gender identity, sexual orientation, national origin, ethnicity or ancestry, religious belief, or English language proficiency. Achieving environmental justice requires (i) the meaningful involvement of all people with respect to the development, implementation and enforcement of environmental laws, regulations and policies, including climate change policies; and (ii) the equitable distribution of energy and environmental benefits and environmental burdens.[11]

Numerous studies have shown that communities of color, low-income neighborhoods, indigenous populations, and neighborhoods with high percentages of residents with limited English proficiency face disproportionately higher exposure to pollution, public health and climate risks, and bear a higher energy burden when compared with other communities.[12] This disproportionate burden often stems from the cumulative impacts of many factors, including historical implementation of housing, transportation and energy infrastructure siting policies; lack of economic opportunities or educational resources; and public health issues. Environmental Justice (EJ) populations in Massachusetts are defined in the 2021 Climate Law.[13] Massachusetts' Environmental Justice Policy, updated in 2021 to align with the 2021 Climate Law, seeks to ensure environmental, energy, and climate benefits for EJ neighborhoods while minimizing harm to the most vulnerable populations in our Commonwealth.

[11] Section 56 of the 2021 Climate Law (Chapter 8 of the Acts of 2021).

[12] De Moura, Maria Cecilia Pinto, et al., "Inequitable Exposure to Air Pollution from Vehicles in Massachusetts: Who Bears the Burden?" Union of Concerned Scientists, 2019, http://www.jstor.org/stable/resrep24098. Accessed 6 May 2022; Bullard, Robert D., et al., "Toxic Wastes and Race at Twenty 1987—2007," United Church of Christ, 2007, https://www.ucc.org/wp-content/uploads/2021/03/toxic-wastes-and-race-at-twenty-1987-2007.pdf; Jbaily, A., Zhou, X., Liu, J. et al., "Air pollution Exposure Disparities Across U.S. Population and Income Groups," Nature 601, 228–233 (2022). https://doi.org/10.1038/s41586-021-04190-y; Tessum, Christopher W., et al. "Inequity in Consumption of Goods and Services Adds to Racial–Ethnic Disparities in Air Pollution Exposure." Proceedings of the National Academy of Sciences of the United States of America, vol. 116, no. 13, 2019, pp. 6001–06, https://www.jstor.org/stable/26696656. Accessed 6 May 2022.

[13] "Environmental justice population" is defined as a neighborhood that meets 1 or more of the following criteria: (i) the annual median household income is not more than 65 per cent of the statewide annual median household income; (ii) minorities comprise 40 per cent or more of the population; (iii) 25 per cent or more of households lack English language proficiency; or (iv) minorities comprise 25 per cent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 per cent of the statewide annual median household income; provided, however, that for a neighborhood that does not meet said criteria, but a geographic portion of that neighborhood meets at least 1 criterion, the secretary may designate that geographic portion as an environmental justice population upon the petition of at least 10 residents of the geographic portion of that neighborhood meeting any such criteria; provided further, that the secretary may determine that a neighborhood, including any geographic portion thereof, shall not be designated an environmental justice population upon finding that: (A) the annual median household income of that neighborhood is greater than 125 per cent of the statewide median household income; (B) a majority of persons age 25 and older in that neighborhood have a college education; (C) the neighborhood does not bear an unfair burden of environmental pollution; and (D) the neighborhood has more than limited access to natural resources, including open spaces and water resources, playgrounds and other constructed outdoor recreational facilities and venues.

The Commonwealth's successful transition to a clean and green energy economy requires the input and participation of all of Massachusetts' socially and economically diverse communities. We must facilitate the adoption of necessary technologies by low- and moderate-income residents and commit to stakeholder engagement practices that overcome language and socio-economic barriers. To achieve widespread market deployment of technologies such as EVs and heat pumps, the Commonwealth will need to reach people in rural areas, Gateway Cities, immigrant communities, working class neighborhoods, indigenous populations, and communities of color. The goals set in this 2025/2030 Plan require broad communication with diverse audiences, including consumers as well as the workforce that will help build the necessary energy infrastructure and technologies. Successful implementation requires that the Commonwealth engage with community representatives throughout the state to make responsible and fair decisions about the siting of these projects. In making important siting decisions, the state must consider the ways in which EJ populations have historically been impacted. The Commonwealth must encourage the ownership of renewable resources by EJ populations and increase access to these renewable energy resources in ways that align with the Commonwealth's responsible land use goals.

Picture 3: Community Informational Meeting on Environmental Justice in New Bedford. Photo credit: Sandra Andrade

To make clean energy work for all communities, the Commonwealth must proactively address some of the obstacles that low- and moderate-income residents and EJ populations face in transitioning to clean energy. The high upfront cost of new technologies is one barrier. The split, and sometimes competing, incentives between landlords and tenants also pose a significant challenge for the installation of cost-saving technologies such as heat pumps and electric vehicle charging stations. Limited English proficiency can be a barrier to accessing incentives or participating in public meetings where decisions are made about state energy efficiency programs.

The Commonwealth can equitably achieve net zero in 2050 only if enabling policies are designed to reflect the racial and economic diversity of the Commonwealth. Achieving the Commonwealth's emissions reduction limits and sublimits requires commitment at all levels of government. Future policies around clean energy, decarbonized buildings, and electrified transportation need to be affordable and accessible for low-income residents. All policy and regulatory decisions must involve processes that enhance public involvement and accessibility. Further, clean energy job creation and education should target historically disadvantaged low-income populations. These are important factors of Massachusetts' approach to reaching the net zero future and the intermediate emissions limits and sublimits.

2.1 ENVIRONMENTAL JUSTICE POLICY

In recent years, the Commonwealth has devoted significant resources toward developing a comprehensive EJ policy framework, with agencies establishing EJ strategies tailored to their specific authority, mission, and programs.[14] This work has been augmented and accelerated by the 2021 Climate Law, which considers the cumulative effects on public health, transportation, housing, and state siting and permitting actions. The most recent iteration of the Environmental Justice Policy was released on June 24, 2021. This policy commits to providing resources to serve EJ populations and it will guide implementation of the 2025/2030 CECP. Thus, this Plan includes considerations for targeting additional financial resources and technical assistance to EJ populations to enable the clean energy transition. Specifically, Massachusetts' Environmental Justice Policy states:

Working with EJ populations, EEA will take direct action as part of the implementation of this Policy to restore degraded natural resources, to increase access to open space and parks, to address environmental and health risks associated with existing and potential new sources of pollution, to appropriately address climate change, and to improve overall quality of life by:

- Enhancing opportunities for residents to participate in environmental, energy, and climate change decision-making.
- Enhancing the environmental review of new or expanding significant sources of environmental burdens in these neighborhoods by requiring cumulative impacts analysis that includes transportation and transit issues, housing, and public health vulnerabilities.
- Ensuring that residents are prepared for and resilient to the effects of climate change (such as heat island effect or flooding) and ensuring that these effects are minimized during development.
- Ensuring that existing facilities in these neighborhoods comply with state environmental, energy, and climate change rules and regulations.
- Ensuring these neighborhoods benefit from positive impacts of environmental programs, grants and investments.
- Encouraging investment in responsible economic growth in these neighborhoods where there is existing infrastructure, in particular where an opportunity exists to restore a degraded or contaminated site and encourage its clean, productive and sustainable use.
- Facilitating local residents' connection with governmental, labor union, community college, or other training opportunities in environmental fields.
- Ensuring that positive economic development that is consistent with environmental protections is a chief priority for EJ populations throughout the Commonwealth.

[14] EEA's equity framework for this Plan seeks to comply with the requirements of Title VI of the Civil Rights Act of 1964, the Massachusetts Executive Branch's Language Access Policy, and the EEA Environmental Justice Policy.

2.2 ADVANCING EQUITY THROUGH DECARBONIZATION

Consistent with the commitment made in the Environmental Justice Policy, the implementation of this 2025/2030 CECP will place an equity lens on all policy and program development and deployment, including efforts to: (a) engage EJ populations with culturally appropriate outreach in multiple languages, (b) prioritize climate investments in EJ neighborhoods while ensuring that improvement actions do not induce the displacement of residents of those neighborhoods, (c) develop metrics by which we can gauge progress over time, especially for tracking air quality in EJ neighborhoods, (d) advance policies to reduce the cost of clean energy for low- and moderate-income residents, (e) ensure workforce development training and education for incumbent workers and new entrants to the work force, prioritizing traditionally hard-to-reach and EJ populations, and (f) minimize negative outcomes on EJ populations, particularly those disproportionately affected by historical development, permitting, and siting decisions.

COMMUNITY ENGAGEMENT

As a part of the Commonwealth's commitment to robust and inclusive public policy deliberation, Massachusetts government agencies should implement this 2025/2030 CECP by utilizing best practices for enhanced community engagement efforts, particularly when implementing programs that could affect EJ populations. Such practices include, but are not limited to:

- Developing Language Access Plans (LAP) and Public Involvement Plans (PIP) that provide an agency-wide and consistent approach to community engagement and the provision of language services.
- Scheduling public meetings or hearings at locations and times convenient for neighborhood stakeholders, and in consideration of public transportation availability.
- Encouraging permit applicants to hold pre-application meetings with the local community, and providing the applicants with EJ organization or stakeholder contact lists and identified non-English media outlets.
- Contacting local sources to obtain the most up-to-date, granular, and accurate information regarding language needs of a neighborhood, including but not limited to local health boards, public school districts, community centers, and community-based organizations for the purpose of obtaining interpreters and providing translations of key documents.
- Translating public notices and other key public engagement documents into languages that are spoken by 3% or more of the population in neighborhoods where persons with limited English proficiency reside.
- Offering interpreters and translated documents at public meetings as appropriate and upon request.
- Establishing one or more local information repositories that are convenient and accessible for the impacted community, as well as providing availability of information online, on a case-by-case basis.

- Gathering and utilizing community-specific local media contacts (based on the culture of the community).
- Employing collaborative approaches to problem-solving, including public deliberation and consensus-building, to the greatest extent possible, to address public concerns.
- Providing effective and early notices to neighborhoods potentially impacted by a decision to solicit input in a timely and meaningful fashion, and providing clear guidance on applicable grievance and appeal procedures.
- Providing information, training, and assistance to EJ populations regarding grant applications and environmental, energy, or climate change regulations to assist them with compliance and sustainability.
- Utilizing creative and community-specific methods to effectively communicate with and engage EJ populations, including but not limited to:
- Utilizing a city or town's public outreach methods of communication.
- Sending notifications to local and non-English TV channels, radios, and newspapers.
- Hiring a community liaison who can utilize their existing networks.
- Posting flyers and hosting information events at houses of worship, schools, farmers markets, senior centers, libraries, community centers.
- Sending notifications through the mobile messaging methodologies.
- Creating a translation-enabled website for posting project and meeting notifications, project information, and options for submitting comments/feedback.
- Getting to know the community with a door-to-door notification and sign-up campaign.
- Using social media to post about the project and engagement opportunities, and asking local partners to assist with positing on their own social media channels.

MONITOR AIR QUALITY IN ENVIRONMENTAL JUSTICE COMMUNITIES

The transition to clean energy must benefit EJ populations who have suffered historically and disproportionately from the direct effects of air pollution caused by fossil fuel combustion. Stakeholder feedback on this Plan has identified the need for expanded community-based air quality monitoring to help inform the development and implementation of the air quality strategies, as well as to measure progress on this effort.

The Massachusetts Department of Environmental Protection (MassDEP) operates a statewide network of 23 air monitoring stations, many of which are located in communities with EJ populations. While these air monitoring stations provide daily pollution levels and track pollution levels over time, additional air monitoring data in the neighborhoods where people live, work, and play would provide more accurate and granular data to assist future policy decisions.

MassDEP is taking steps to provide more air monitoring resources to overburdened communities by increasing the number of monitoring stations and providing hundreds of air sensors to cities and towns.

Increased local air monitoring will better inform communities, as well as help us measure progress and develop policies and programs to address geographically specific areas bearing the burden of pollution.

In 2021, MassDEP partnered with city officials and the local community to establish an ongoing community-based air quality monitoring project in Chelsea, Massachusetts. The community chose locations for a permanent monitor station that records fine particulate matter (PM2.5) and volatile organic compounds, and also placed nine PM2.5 sensors in locations around Chelsea. The monitoring data is being used to increase local awareness of air pollution. Residents are alerted to elevated levels of air pollutants so they can avoid exposure (such as limiting strenuous outdoor activity) and identifies polluting sources so that emissions reduction and mitigation strategies can be taken to protect residents' health.

Building off the Chelsea effort, MassDEP developed a new grant program that provides up to 10 PM2.5 air sensors to individual communities across the Commonwealth to place throughout their city or town, with a focus on helping EJ communities identify sources of pollution so that emissions reduction and mitigation strategies can be taken to protect residents' health. In January 2022, MassDEP announced the award of 292 air sensors to 39 communities that are now being deployed and operated by these communities. MassDEP plans to continue additional air sensor grant opportunities in the future.[15]

PRIORITIZE INVESTMENTS IN ENVIRONMENTAL JUSTICE COMMUNITIES

Massachusetts has a history of supporting clean energy access to low- and moderate-income customers. Between 2015 and 2020, the Massachusetts Solar Loan Program offered financing to consumers and the program has targeted low- and moderate-income customers since 2017. The program resulted in more than 5,800 loans, with 79% provided to low- and moderate-income customers. Additionally, through the Solar Massachusetts Renewable Target (SMART) program, the program has increased incentives for low-income customers and has included a carve-out to protect the value of the incentive for low-income customers. However, these efforts could be expanded to increase low-income and EJ populations' access and ownership of solar. Massachusetts will prioritize investments in clean energy, clean

Picture 4. MBTA Bus Driving through Boston

[15] MassDEP has secured American Rescue Plan Act (ARPA) direct federal grant funding to add monitoring stations in overburdened communities and upgrade existing monitors and has also applied for competitive ARPA grant funding to further enhance air monitoring in urban EJ populations areas near high traffic roadways. MassDEP is also co-leading a community-based air quality monitoring workgroup of northeast and mid-Atlantic states facilitated by the Georgetown University Transportation Climate Initiative. This workgroup is sharing information among states and building capacity within agencies and communities to develop and maintain community-based air quality monitoring programs to help inform and shape the development and implementation of clean transportation policies and programs. The workgroup is focusing its efforts in particular on frontline communities that have borne a disproportionate exposure to air pollution, much of which comes from mobile sources.

transportation, and clean environment that will benefit EJ populations. For example, the Massachusetts Bay Transportation Authority (MBTA) Bus Modernization program aims to have 100% of all buses in service be EVs by 2040 and provide bus service to 275,000 additional residents. As another example, the multifamily zoning requirements for MBTA Communities, codified in Section 3A of M.G.L. c. 40A, requires that an MBTA community have at least one zoning district of reasonable size in which multi-family housing is permitting as of right and meets other criteria set for in the statute. Further, investments in EVs will significantly benefit EJ neighborhoods by prioritizing fleets of vehicles operating in those neighborhoods, including school buses, vehicles for hire, and delivery trucks.

MAKE CLEAN ENERGY TECHNOLOGIES AFFORDABLE TO LOW- AND MODERATE-INCOME RESIDENTS

Massachusetts' energy efficiency and energy transition programs, implemented via Mass Save®, provide specific and targeted incentives for low- and moderate-income customers. The most recent 3-year Energy Efficiency Plan, approved on January 31, 2022, requires the state to identify targeted equity initiatives, including investments to serve low and moderate-income customers, customers with limited English proficiency, small businesses, renters, and landlords, and to establish a dedicated budget for workforce development. The program will cover 100% of the cost for weatherization for low- and moderate-income customers. Overall, the energy efficiency efforts of the future will focus on leveraging community and municipal partnerships to increase participation in energy efficiency programs by historically underserved populations.[16] Additionally, all programs and initiatives contained in this 2025/2030 CECP aim to increase the participation of EJ populations in the transition to a clean energy future. Mitigation of any potential cost increases associated with the clean energy transition will be explored through consumer protection programs.

ENGAGE A DIVERSE CLEAN ENERGY WORKFORCE

Making significant investments in clean energy technology across Massachusetts will require a well-trained, diverse workforce. The Massachusetts Clean Energy Center (MassCEC) has begun to make unprecedented investments in equity-focused workforce development programs, resources, and organizations to meet this challenge.

Recognizing that some populations have faced unique challenges accessing career opportunities in the clean energy industry due to a range of barriers, MassCEC's strategic workforce investments will create career pathways for women, minorities, and EJ populations which will enable a diverse clean energy industry to flourish, resulting in a sustainable economy.

These investments include but are not limited to: supporting community-based organizations that serve EJ populations to provide workforce training and support; funding support services such as child care, English to Speakers of Other Language classes, supplemental education, and public transit passes to help individuals compete for and access clean energy jobs; providing targeted grants to women and minority

[16] Massachusetts Department of Public Utilities Order in Dockets 21-120 through 21-129. Can be accessed at https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14461268.

owned clean energy businesses; and helping existing clean energy employers attract and retain diverse employees.

MINIMIZE NEGATIVE OUTCOMES

Decarbonization of the economy will require significant investments in clean energy infrastructure. To consider, evaluate, and ultimately regulate the building of this infrastructure and to improve inclusivity in decision-making, all review, siting, and permitting processes need enhanced community engagement and public participation. As an example, the Energy Facilities Siting Board (Siting Board) is responsible for reviewing proposed large energy facilities including power generating facilities, electric transmission lines, intra-state natural gas pipelines, and natural gas storage tanks. The Siting Board is committed to continuing to use enhanced public participation procedures, which include providing translated documents to those whose primary language is not English. The Siting Board commits to providing interpretation services at public hearings upon request and in languages that it has pre-identified as significant for a specific geographic area. In addition, the Siting Board will continue to improve and use enhanced analysis of impacts and mitigation procedures in its review of proposed energy facilities, including evaluating the cumulative health impacts for proposed facilities, and considering such information in its determinations. Decisions issued by the Siting Board will continue to include measures to mitigate such impacts for the affected communities, with enhanced review required where EJ populations are present.

CHAPTER 3: EMISSIONS SUBLIMITS AND PATHWAYS

To develop GHG emissions limits and sector-specific sublimits for the 2025/2030 CECP, Massachusetts has updated and refined the analysis performed for the 2050 Roadmap Study. The updated analysis reflects the impacts of key policies in the transportation, electricity, and industrial sectors. It evaluates five different clean heat pathways to assess near- and long-term policy approaches for decarbonizing the residential and commercial industrial heating (and cooling) sectors, as well as other sectors of the economy. The analysis identifies the most cost-effective way to meet statutory GHG emissions limits for 2030, 2040, and 2050. In addition, the analysis informs the 2025 economy-wide GHG emissions limit and the 2025 and 2030 sector-specific GHG emissions sublimits. This chapter outlines the 2025 economy-wide GHG emissions limit and the 2025 and 2030 sector-specific GHG emissions sublimits. This chapter also explains the details on the various clean heat pathways analyzed.

3.1 SETTING SECTOR-SPECIFIC SUBLIMITS FOR 2025 AND 2030

The 2021 Climate Law identified several sectors for the purpose of setting sector-specific GHG emissions limits that correspond to each statewide interim limit. Massachusetts' GHG Emissions Inventory was established as the primary method to track compliance with the GWSA of 2008.

RESIDENTIAL HEATING AND COOLING

The 2021 Climate Law stated that a sector-specific GHG emissions sublimit must be set for Residential Heating and Cooling as a component of each statewide interim limit. All emissions associated with combustion of fuels in residences will be categorized as Residential Heating, consistent with the Residential sector of Massachusetts' GHG Emissions Inventory. In addition to space heating, Residential Heating includes emissions from all on-site combustion of fuels for water heating, cooking, and other needs. Residential Cooling is typically serviced by electricity, and emissions associated with air conditioning are accounted for alongside all other emissions from the generation of electricity under the Electric Power sublimit. Electric heating systems, including resistance heaters as well as heat pumps, are also accounted for under the Electric Power sublimit.

COMMERCIAL & INDUSTRIAL HEATING AND COOLING

This category includes all GHG emissions associated with heating in commercial and industrial facilities, plus all energy uses to manufacture goods, consistent with the Commercial sector and Industrial sector of the Massachusetts GHG Emissions Inventory. In addition to space heating, these sectors include emissions from all on-site combustion of fuels for water heating, cooking, and a range of commercial and industrial processes. All electricity usage from commercial and industrial facilities is counted under emissions for the Electric Power sublimit.

TRANSPORTATION

Emissions from the Transportation sector include emissions from the combustion of fuels for all highway and off-road vehicles in the Commonwealth, including cars, trucks, buses, trains, construction vehicles, farm equipment, and aviation, consistent with Massachusetts' GHG Emissions Inventory. Emissions

from aircraft are estimated through the sale of aviation fuels prior to departure. The emissions of all departing aircraft are tracked while the emissions of all arriving aircraft are not. This is a standard approach for tracking GHG emissions of air travel.[17]

ELECTRIC POWER

Emissions in the Electric Power sector include those from (a) combustion of fuels in power plants physically located in Massachusetts, and (b) the emissions from the electricity generated in or imported into the ISO-New England's system to meet the electricity demand in Massachusetts. The emissions accounting from the power sector for Massachusetts also reflects the annual production of renewable and clean energy credits tracked through the New England Power Pool Generation Information System (NEPOOL GIS) in accordance with the Commonwealth's Renewable Portfolio Standard and Clean Energy Standards.[18]

NATURAL GAS DISTRIBUTION AND SERVICE

The emissions associated with Natural Gas Distribution and Service include the carbon dioxide equivalent of fugitive methane from gas pipelines, services, compressors, and meters, consistent with the Natural Gas Distribution and Natural Gas Transmission sectors of Massachusetts' GHG Emissions Inventory. This category does not include the emissions from the combustion of natural gas for residential, commercial, or industrial heating or other energy uses. Emissions from combustion of natural gas are counted in the Residential Heating and Cooling and the Commercial and Industrial Heating and Cooling sectors described above. Emissions from the combustion of natural gas for electric power are included in the Electric Power sector. Significant academic research has investigated approaches to estimating the volume of leaking gas; both the U.S. Environmental Protection Agency (EPA) and MassDEP continuously monitor this research and incorporate updates to their methodology as new information becomes available. Since assumptions about future emissions in this category have been developed to align with existing emissions accounting methodologies, any update to inventory accounting procedures would require updating forecasted emissions and potentially the baseline emissions in 1990.

INDUSTRIAL PROCESSES

Emissions from the Industrial Processes sector include the direct emissions of carbon dioxide as a byproduct of lime production and the carbon dioxide equivalent of fluorinated gases (F-gases) used as refrigerants, flame retardants, and in the production of certain types of insulation, consistent with the same category in the Massachusetts GHG Emissions Inventory. In March 2022, EPA released an update to its methodology for estimating emissions from F-gases, the largest component of the Industrial Processes subsector. Since estimates of future consumption and emissions of F-gases is consistent with

[17] MassDEP has proposed to update its treatment of fuel consumption for international flights, moving such fuel consumption out of the Transportation sector and into a "bunkering" category, aligning with emissions accounting practices established by the United Nations Framework Convention on Climate Change (UNFCCC). The sublimit for this sector assumes this proposal is adopted.

[18] Each megawatt hour (MWh) of clean energy produces one unit of credit. To satisfy the regulatory requirements, each unit of credit must be "retired" after being counted for compliance.

the previous methodology, incorporating EPA's new methodology into Massachusetts' GHG Emissions Inventory may require updating forecasted F-gas emissions in the future.

ALL OTHER EMISSIONS SOURCES

Using the definitions described above, the sublimits account for nearly all sources of gross emissions in the Commonwealth. Only GHG emissions associated with agriculture, solid waste decomposition in landfills, and wastewater disposal are not represented in a sector-specific sublimit. Although there is not a sector-specific sublimit for these emissions sources, Table 3.1 below includes these other emissions sources to show the total gross GHG emissions economy-wide for Massachusetts.

Table 3.1 shows the 1990 historical actual GHG emissions from each sector, and the 2025 and 2030 columns show the GHG emissions sublimit for each sector. The right-hand columns show the percent reduction for each of the sector relative to the 1990 level.

Table 3.1. Economy-Wide GHG Emissions Limits and Sector-Specific Sublimits for 2025 and 2030

Sublimits	Gross Emissions ($MMTCO_2e$)			% Reduction (Increase) from 1990	
	1990	2025	2030	2025	2030
Residential Heating and Cooling	15.3	10.8	7.8	29%	49%
Commercial & Industrial Heating and Cooling	14.2	9.3	7.2	35%	49%
Transportation	30.2	24.9	19.8	18%	34%
Electric Power	28.0	13.2	8.4	53%	70%
Natural Gas Distribution & Service	2.3	0.4	0.4	82%	82%
Industrial Processes	0.7	3.6	2.5	(449%)	(281%)
All Others	*3.4*	*1.0*	*0.9*	*70%*	*73%*
Total	**94.0**	**63.2**	**47.0**	**33%**	**50%**

The 2021 Climate Law requires the Commonwealth to adopt statewide goals to reduce GHG emissions and increase carbon sequestration on natural and working lands. While the accounting for how Massachusetts' natural and working lands (including the associated land-based ecosystems and derived products) emit and absorb GHG emissions is complex, dynamic, and uncertain (see Chapter 8 and Appendix C), Massachusetts is committing to the goals of maintaining the current level of net emissions from natural and working land through 2025 (estimated to be -7.0 $MMTCO_2e$ per year) and achieving a net NWL emissions reduction of 25% below 1990 level by 2030 (estimated at -7.4 $MMTCO_2e$ per year).

Table 3.2. Emissions Goals for Natural and Working Lands

Goal	Net Emissions ($MMTCO_2e$)				% Reduction (Increase) from 1990	
	1990	2025	2030		2025	2030
Natural and Working Lands	-5.9	-7.0	-7.4		19%	25%

Note: Negative numbers in Net Emissions are the amount of emissions sequestered each year. Net emissions from inland wetlands not yet accounted for.

3.2 UPDATED PATHWAYS ANALYSIS TO SET LIMITS AND SUBLIMITS FOR 2025 AND 2030

The sector-specific GHG emissions sublimits described above were developed using a decarbonization pathways analysis that includes updates and refinements to the 2050 Roadmap Study. The Roadmap Study emphasized pathways to reach net zero in 2050 and focused on a range of long-term technological changes. The refined analysis uses updated assumptions and focuses on 2025 and 2030, ensuring that Massachusetts meets a GHG emissions limit of at least 50% below 1990 level in 2030. Other refinements include updated energy demand forecasts from the U.S. Energy Information Administration's (EIA's) 2021 Annual Energy Outlook (AEO). These updated forecasts include estimates of near-term impacts from the COVID-19 pandemic, such as a reduction in passenger vehicle-miles traveled in 2020, as well as an adjusted travel demand forecast based on EIA's anticipation of long-term trends for commuting, telework, and travel.

The pathways analysis to reach 50% emissions reduction in 2030 and net zero in 2050 does not directly simulate policy decisions, but it simulates certain policy outcomes and helps inform policymaking. The analysis reflects Massachusetts statutory requirements and federal actions that will directly affect GHG emissions from the state. For example, the analysis includes: (a) the latest authorization for offshore wind procurements in Massachusetts and other New England states, (b) compliance with the recently finalized and newly proposed California ZEV standards that will affect the adoption rate of zero-emission light, medium, and heavy-duty vehicles, (c) recent and proposed regulatory updates for non-energy sector emissions sources, and (d) how the updated Renewable Portfolio Standard and upcoming changes to the Clean Energy Standard are anticipated to affect the allocation of New England's regional electricity grid emissions to Massachusetts.[19]

Due to uncertainty in how life-cycle emissions of clean fuel alternatives and how regional, national, and global sequestration markets will interact with the GHG accounting in Massachusetts to comply with the GWSA, the simulations target a 90% reduction in gross GHG emissions in 2050 relative to 1990, rather than the statutory minimum requirement of 85%. This approach is consistent with the prior assumptions used in the 2050 Roadmap Study. In addition to various updates, this new analysis focuses on the future of decarbonizing heating in Massachusetts buildings. The 2050 Roadmap Study identified electric heat pumps as a key technology to reduce emissions from space and water heating, alongside a limited role for drop-in fuel alternatives. A transition from existing natural gas, fuel oil, and propane boilers to electric heat pumps raises several key deployment considerations evaluated in this analysis, including:

- Existing Heating, Ventilation, and Air Conditioning (HVAC) systems have long operating lives and are most cost-effectively replaced at the end of their lives, which in turn limits the feasible pace of heat pump adoption.
- Electric heat pumps perform less efficiently at very low temperatures, and while current heat pump technology can meet the heating needs of most buildings in Massachusetts' climate, the

[19] The modeling also reflects proposed updates to aviation fuel accounting, as well as how that update impacts the 1990 baseline and thus the 2030, 2040, and 2050 gross emissions limits.

use of heat pumps in the coldest hours of the year can significantly increase electricity demand during those hours, and thereby can increase the need for electricity system upgrades.

- Continued investments in natural gas pipelines can create stranded costs that must be borne by either remaining gas ratepayers or gas utility shareholders. Thus, any additional pipeline investments must be made with deliberation and care.

To analyze these key issues in developing the plan to achieve the 2025 and 2030 GHG emissions limits and sublimits, EEA developed five different clean heating pathways for Massachusetts, ranging from heavy reliance on clean fuels to aggressive full building electrification. Each scenario reflects a set of assumptions that characterize a possible approach to meet the 50% GHG economy-wide emissions reduction in 2030, toward a net zero economy in 2050. The key variation among the different clean heat scenarios is the turnover and replacement of existing building furnace and boiler stock. The model simulates the retirement of HVAC systems when each piece of equipment reaches its end-of-life, and replacement with new equipment, such as electric heat pumps. Differentiating between heating and cooling replacements allows the simulation of the partial electrification of a building when its air conditioner is replaced with a heat pump (or installing a heat pump for cooling in buildings that previously did not have air conditioners) before its furnace or boiler is ready to be replaced. From simulating stock turnover to arrive at a new inventory of equipment, hourly energy demand is then estimated by aggregating hourly energy usage profiles for the equipment installed. The analysis includes optimizing the investments needed in the electricity systems, along with fuel production and delivery systems to meet the energy demand while adhering to the statutory GHG emissions limits and anticipated clean energy resources deployed.[20]

Picture 5. Two HVAC Technicians Installing a Heat Pump

No single scenario represents a forecast or the "right answer" for how Massachusetts must meet its climate goals. Instead, comparing the outcomes of the various pathways provides insights into the tradeoffs between different approaches and the pace of decarbonization. For more detail on the methodology behind the pathways analysis and the specific modeling tools employed, please see Appendix A.

CLEAN HEAT SCENARIOS

The pathways analysis evaluated five scenarios to represent the spectrum of decarbonized heat strategies and explore the key implementation questions described above. Each scenario relies on a suite of available clean heating technologies: traditional furnaces and boilers operating with a blend of clean fuels; all-electric ground-source and air-source heat pumps; and "partial-home" heat pump

[20] All resource costs are based on either U.S. Department of Energy, Energy Information Administration's forecasts, or other literature review, including the cost and supply of the feedstock for biofuels and biogas.

systems deployed in instances where a heat pump air conditioner is installed before a furnace or boiler is ready to be retired. Table 3.3 below describes each scenario:

Table 3.3. Clean Heat Scenarios

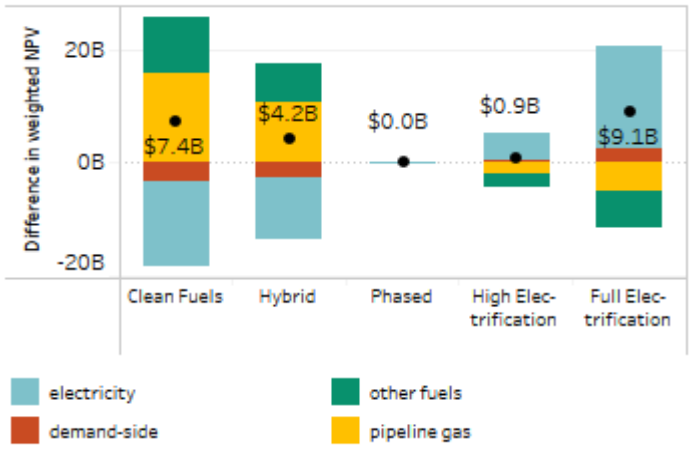
Scenario Title	Scenario Description
Reference	Today's trend of residential customers switching from oil and liquid propane to gas heating continues. This scenario does not achieve the GHG emissions limits as required by the GWSA.
Clean Fuels	Same heating technology adoption as Reference scenario, but includes extensive reliance on carbon neutral gas and liquids to meet GHG targets.
Hybrid	Rapid adoption of hybrid utilization of fossil-fuel and electric heat pumps by 2030. Combustion backups remain common at low temperatures, resulting in moderate demand for RNG and biofuel in 2050.
Phased	Rapid adoption of both partial- and whole-home heat pump systems but allows for hybrid fossil-fuel and electric heat pump systems in the 2020s and then whole home retrofits thereafter. Some use of clean fuels in 2050.
High Electrification	Rapid adoption whole-home heat pumps. Some use of clean fuels in 2050. Most similar to the "All Options" pathway from the 2050 Roadmap Study.
Full Electrification	Maximum adoption of whole-home air-source and ground-source heat-pumps at the rates required to no longer use fuels in buildings in 2050.

3.3 DEFINING THE 2025 AND 2030 GHG EMISSIONS LIMITS AND SUBLIMITS BASED ON ANALYTICAL RESULTS

The Commonwealth is adopting the GHG emissions limits and sublimits for 2025 and 2030 using the "Phased" scenario used in the analysis because it presents both long-term and near-term benefits over other building decarbonization approaches analyzed. The Phased scenario drives progress toward widespread electrification of buildings in 2050 by deploying a combination of whole-home and partial-home heat pumps through 2030, leveraging as many intervention points as possible to maximize the cost-effective electrification of stock. This approach can quickly increase adoption of electric heat pumps in the near-term, allow consumers to learn by experience, and develop a workforce to help reduce challenges associated with conversions. After 2030, the Phased scenario emphasizes the continued deployment of whole-home heat pumps alongside the conversion of all partial systems to fully electric buildings, approaching the same levels of whole-home deployment as in the High Electrification case in 2050. This scenario avoids locking in fossil fuel infrastructure and equipment costs, and the higher risk and higher cost associated with the scenarios dependent on clean fuels.

All five scenarios include the deployment of envelope upgrades—insulation, windows, and roof—when those components are due to be replaced. Building envelope upgrades are a foundational strategy for reducing both energy system costs and GHG emissions. In addition, all five scenarios incorporate near complete electrification of the light-duty vehicle fleet and significant electrification of heavy-duty vehicle fleets by 2050, driven by California's current and proposed ZEV standards. Electrification of vehicle fleets is a dominant strategy in the transportation sector. Precise electricity sector buildouts vary across different building electrification outcomes. Across all scenarios, New England continues to decarbonize its electricity system by deploying offshore wind and solar resources, as well as increasing regional transmission capacity to integrate clean resources from as broad a geographic area as possible, especially imports from New York and Québec. As in the 2050 Roadmap Study, a small amount of residual thermal generation represents a cost-effective approach to providing grid reliability without exceeding emissions targets. Full analytical results are presented in Appendix A, including key benchmarks.

Figure 3.1. Cost Comparison of Each Modeled Scenario

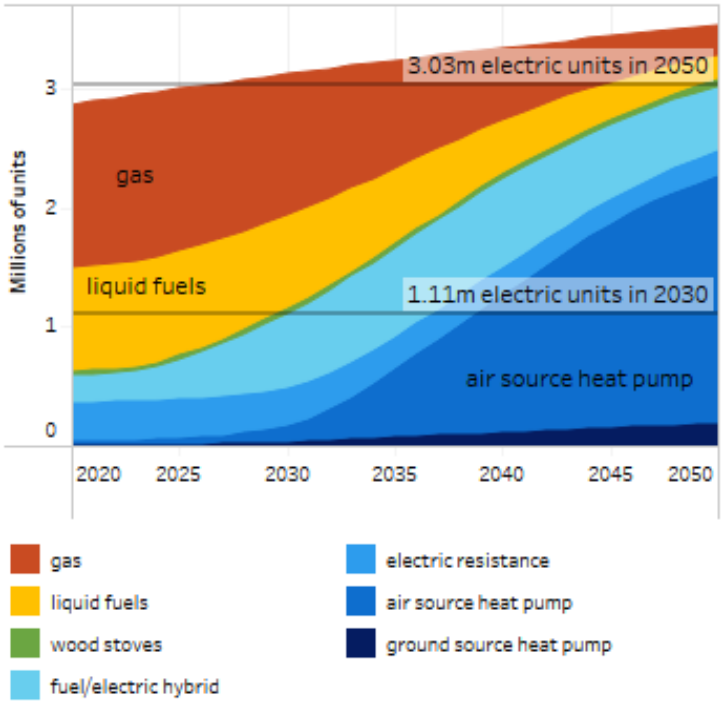


Key Pathway Feature: Widespread Electrification by 2050

The Commonwealth's dominant building decarbonization strategy is electrification. This is currently expected to be the least-cost and lowest-risk pathway compared to approaches with high demand for renewable liquid and gaseous fuels. Future analyses will be needed to update the potential costs and risks associated with different pathways, particularly as technology costs change over time. Based on the best available information today, Figure 3.1 compares the cost of each modeled scenario through 2050 on a present value basis. The Phased and High Electrification scenarios have the lowest total cost. Although the Hybrid and Clean Fuels scenarios avoid investment in demand-side electrification and significant electric system investments, those savings are offset by increased pipeline infrastructure costs and the costs of renewable and synthetic natural gas. If the long-term supply and cost of bioenergy resources do not meet current projections or if transportation systems are not electrified as heavily as assumed in this analysis (which would require more bioenergy resources to power transportation systems), future supply constraints on bioenergy resources would likely increase the cost of clean fuels and hybrid pathways above and beyond these estimates.

Pursuing an electrification-focused strategy allows the Commonwealth to mitigate the risk and additional cost of pipeline gas infrastructure investments. All scenarios modeled show declining consumption of pipeline gas. Thus, any capital costs and other fixed costs associated with the gas pipeline systems result in an increase in gas delivery price. While all scenarios assessed indicate that the Commonwealth will need to seek changes to the existing gas utility business models and reform retail rate structures to ensure equity and affordability, electrification-focused approaches create the opportunity for regulators and utilities to promote a managed transition by gradually retiring and decommissioning gas assets as pipeline gas throughput declines, mitigating substantial increases to gas distribution rates.

Figure 3.2. Residential Space Heating Stock, Phased Scenario



Key Pathway Feature: Rapid, Cost-Effective Deployment of Heat Pumps by 2030

Despite the advantages of a decarbonization pathway that focuses on electrification, transitioning buildings to whole-home heat pumps can be costly in some circumstances, and the opportunities to replace existing heating appliances are infrequent. While heat pump technology available today can and increasingly does provide whole-home heating in the Massachusetts climate, heat pumps can also be deployed to replace an air conditioner or provide cooling for those who currently do not use air conditioners, while partially electrifying a building's space heating. This type of retrofit is typically less expensive compared to a whole home retrofit and a phased approach increases the adoption rate in the early years. While partial electrification does avoid costs in the 2020s, these savings must be traded off against increased investments to fully electrify buildings after 2030. However, given the current lack of experienced workforce and lack of popular knowledge about heat pumps, a phased approach focuses the near-term efforts on expanding the market for heat pumps, potentially delivering cost and performance benefits in the longer term. This allows for significant efforts needed to augment workforce training, supply-chain scale, contractor knowledge, and consumer awareness of heat pump technology, bearing in mind the urgent need to drive decarbonization efforts forward quickly. Building market capacity toward realistic near-term goals while maintaining long-term goals for widespread electrification is critical for providing good-faith guidance and coordinating gas and electric utility planning. Such efforts can keep energy services reliable and affordable by identifying and planning out near- and long-term electricity grid upgrades and by focusing on deliberate and targeted decommissioning of the gas system, instead of continuing to expand it. These dynamics and policy approaches are discussed in greater depth in Chapter 5.

Key Pathway Feature: Optionality and Flexibility

In addition to electrification, the Phased scenario assumes a 5% reduction in the carbon intensity of pipeline gas by 2030 and a 20% reduction for fuel oils by 2030. Although the analysis favors widespread electrification over any widespread use of bioenergy and synthetic alternatives or green hydrogen for building heating, the GHG emissions rate associated with any continued use of existing fuels and gases will need to decrease significantly. In addition, in almost all scenarios modeled, such fuels will be a part of net zero GHG emissions by 2050, mostly for "hard-to-electrify" sectors, such as certain industrial and commercial processes, as well as for aviation and some niche vehicle duty-cycles. Piloting and evaluating eligible fuels and resources in the near-term is an important step in reducing uncertainties around the cost and supply availability of these fuels in 2050. Thus, all pathways modeled in this analysis assume a blend of bioenergy from certain feedstocks and that these fuels contribute to meeting the Commonwealth's gross emissions limits and sublimits. Future research and deliberation are needed to determine how to integrate these fuels into the Commonwealth's policy portfolio and emissions inventory accounting methodology. This assumption has significant policy implications that will be discussed in Chapter 5.

Overall, pursuing whole-home and partial-building heat pump deployment for retrofitting existing buildings' heating systems and initiating limited pilots of clean fuels alternatives through 2030 builds optionality into the Commonwealth's decarbonization strategy. While existing gas pipeline infrastructure will continue to serve customers through 2030, the declining throughput should motivate efforts to reduce gas system fixed costs as soon as possible. If clean fuels and gases do not become abundant and cheap in the 2030s, the Phased approach will drive important progress toward long-term electrification, ensuring a viable and affordable pathway to a net zero economy.

CHAPTER 4: TRANSFORMING OUR TRANSPORTATION SYSTEMS

4.1 SECTOR OVERVIEW

Transportation is the largest source of GHG emissions in the Commonwealth, responsible for 42% of statewide GHG emissions as of 2019.

Pollution in the transportation sector results from the combustion of fossil fuels in the engines of cars, trucks, airplanes, and other vehicles. In addition to contributing to climate change, our consumption of fossil fuels in the transportation sector is a leading source of toxic air pollution, including particulate matter (PM) and nitrous oxide, that harms human health.

Transportation emissions remained high between 1990 and 2019, before declining dramatically in 2020 as a result of the COVID-19 pandemic. Emissions in the transportation sector have stagnated despite state and federal vehicle emissions standards that have gradually increased the fuel efficiency of vehicles. One major cause of increased emissions is the considerable increase in total statewide vehicle miles travelled (VMT) over the past 30 years. Increasing VMT is a result of growing prosperity: there are more people working more jobs in the Boston and other metro areas than there were in 1990. Growing prosperity also contributes to more discretionary trips made by car, and to individuals and households owning more cars. Passenger vehicle travel in the Commonwealth has grown from 48.9 billion annual miles in 1990 to 61.1 billion annual miles in 2019. Managing the transportation-related impacts of continued population and economic growth on our environment is a challenge that will require continued coordination between climate, housing, and transportation policy at the state and local levels.

Picture 6. Row of Bike Share Bluebikes

The COVID-19 pandemic has had a profound impact on all areas of our economy, particularly transportation, and particularly in 2020. In the immediate term, the COVID-19 pandemic caused a dramatic reduction in travel across most modes, from personal vehicles to public transportation to airline travel. Many office-based businesses transitioned their employees to working from home, and many of these individuals may never return to full-time commuting. Across Massachusetts, cities and towns took advantage of the temporary respite from vehicle traffic to reclaim street space for cyclists and pedestrians or established bus-only lanes to improve bus service. Sales of bicycles and e-bikes increased, as did use of public trails and bike lanes. The studies conducted for this Plan estimate that transportation emissions fell by 22% in the year 2020.

The medium- and long-term impacts of the COVID-19 pandemic on transportation behavior are less clear. While some residents may benefit from reduced commuting, pandemic-induced shifts in long-standing travel patterns have caused a significant reduction in the use of public transit for commuting and related trips, and especially in the use of the MBTA Commuter Rail system. Reduced or eliminated

commuting may also contribute to greater suburban sprawl, as people seek housing farther from downtown, in places in which walking, biking, and using public transit are not often realistic options for errands and other everyday trips. In this way, increased telework can, paradoxically, lead to more vehicle miles traveled. The pandemic also may have slowed the near-term rate of electric vehicle adoption, as complex global supply chains struggle to keep pace with surging demand.

In addition to the growth in passenger-vehicle travel and emissions, emissions from medium and heavy-duty vehicles doubled from 4 $MMTCO_2e$ in 1990 to over 8 $MMTCO_2e$ in 2019, as the amount of freight being shipped to Massachusetts increased throughout this period, and even more so since. With the continuing growth of e-commerce, delivery trucks are becoming a significant source of congestion and emissions on Massachusetts roads, as truck trips from warehouses to stores are replaced by direct distribution to homes and businesses. This often means more diesel vehicles operating in residential neighborhoods. Addressing the emissions and public health impacts of an increasingly decentralized freight distribution system is a critical component of our strategy to address transportation emissions.

Pollution from air travel has increased marginally since 1990, from 4.0 $MMTCO_2e$ in 1990 to approximately 4.3 $MMTCO_2e$ in 2019, the result of a nationwide increase in pre-pandemic airline travel, before collapsing in 2020 due to the pandemic. The technology pathway to zero-emission air travel is unclear and Massachusetts has limited jurisdiction over airline travel. Thus, we anticipate only modest reductions in this area in the next eight years.

GHG EMISSIONS SUBLIMITS FOR THE TRANSPORTATION SECTOR

The 2025 GHG emissions sublimit for the transportation sector is set at 24.9 $MMTCO_2e$, or an 18% reduction from 1990 level. The 2030 GHG emissions sublimit for the transportation sector is set at 19.8 $MMTCO_2e$, or a 34% reduction from 1990 level. Table 4.1 illustrates the gross GHG emissions attributable to the transportation sector in 1990, 2010, 2015, and 2020, compared to the transportation sector sublimits for 2025 and 2030.

Table 4.1. Emissions from Transportation Sector

Transportation	1990	2010	2015	2020	2025	2030
Gross Emissions ($MMTCO_2e$)	30.2	30.8	30.4	23.7	24.9	19.8
% Reduction (Increase) from 1990		(2%)	(1%)	22%	18%	34%

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

In setting this limit, the Commonwealth considered numerous factors, including: the pace at which new transportation technologies such as EVs, including both all-electric vehicles and plug-in hybrid vehicles, are entering the market; existing and upcoming vehicle emissions standards implemented by Massachusetts and California; the likely ongoing impact of COVID-19 on vehicle travel and mobility broadly; the costs and benefits of reductions in different economic sectors; and the best estimate of the impact of potential strategies designed to reduce VMT.

To achieve the 2025 sublimit, the Commonwealth set a goal of 200,000 total EVs on the road and 15,000 public charging stations in 2025. To achieve the 2030 sublimit, the Commonwealth set a goal of 900,000

total EVs on the road. The 2030 EV goal represents a significant increase from the Interim 2030 CECP. This ambition reflects increasing optimism around the long-term trajectory of EV sales given the changed federal policy environment, funding available for Massachusetts for EV charging in the recent federal Infrastructure Investment and Jobs Act (IIJA), new vehicle emissions standards promulgated by California, and some of the additional policies already under development and contained in this plan. To support these vehicles, the Plan includes a target of 75,000 public charging stations by 2030, in addition to expanding the number of charging stations in homes and fleet depots.

4.2 GETTING TO 18% REDUCTION BY 2025 AND 34% REDUCTION BY 2030

The 2025/2030 CECP transportation strategy is focused on two major goals. First, the Commonwealth will achieve a modest reduction in total VMT compared to baseline projections, in spite of continued projected population and economic growth, by providing more Massachusetts residents with more **alternatives to personal vehicles.** As voiced by stakeholders, it is important to our climate policies that the state continue to invest in public transit, encourage building more housing near transit, improve the quality of our bike and pedestrian infrastructure, and invest in thriving downtown communities, both in metro Boston and throughout the Commonwealth. In addition, to sustain some of the emissions reduction caused by increased remote work, it will be important to work with employers and communities to reduce unnecessary travel and support low-carbon commutes wherever possible.

Second, the Commonwealth will rapidly transition the vehicles on our roads to EVs. Electric vehicles, whether battery electric vehicles (BEV) or hydrogen fuel cells vehicles (HFCV), provide superior automotive performance while achieving dramatic reductions in global warming pollution compared to vehicles with petroleum-fueled internal combustion engines. Over the next few years, auto manufacturers are proposing numerous new electric models in all vehicle classes, including sedans, tractor-trailers, and buses. The benefits of BEVs include lower emissions of GHGs and air pollutants, stable and generally lower fuel costs, and generally lower maintenance costs.

The transition to EVs will have a profound impact on household budgets and the state economy. Based on today's technology and energy prices, the average driver in Massachusetts could go from spending over $200 per month on gasoline to about $90 per month on electricity—with greater savings possible through the deployment of vehicle-to-grid technologies or managed charging strategies. Reduced spending on petroleum will mean that the Commonwealth will be more resilient to fluctuations in global energy prices, particularly when an even greater portion of our electricity system is powered with renewable energy.

While the potential benefits of EVs are tremendous, achieving a rapid transition will require the state to overcome many significant barriers to electrification. These barriers include limited availability of EV models and limited charging infrastructure. While in the long run lower battery costs will allow EVs to reach "price parity" with internal combustion vehicles, EVs currently cost significantly more up front. Many consumers are just beginning to understand the benefits of EVs, such as the reduced cost of refueling and the convenience of being able to charge from home, so considerable consumer education will be required. For fleet operators, the transition to EVs presents complex challenges of technology, infrastructure, and logistics.

To ensure that the future of driving is all-electric, Massachusetts will implement **vehicle emissions standards** that require that vehicle manufacturers continue to expand their investments in electric technologies in all classes. The Commonwealth will look to support consumers with **convenient, point of sale rebates** for EV purchases, with targeted additional incentives for low- and moderate- income residents and high mileage drivers. The Commonwealth will look to provide specific and focused support for electrification of vehicles and fleets that are critical from an **equity and public health** perspective, including school buses, transit buses, last-mile delivery vehicles, and vehicles for hire. State programs and electric utility programs will help deploy the **charging infrastructure** necessary to support the EV transition along highways, in parking lots, homes, apartment buildings, and fleet depots.

As the number of EVs on the road increases, **managing electric vehicle charging** will be a growing priority for the Commonwealth, its agencies and departments, and the utilities and municipal light plants. EVs will increase demand on the electricity grid. If most people charge their EVs during hours of peak electricity demand, this additional load could over-stress the grid and require grid investments. Technologies and policies including demand-side management, increased substation capacity, and educating customers on the best times to charge their vehicles will ease the integration of EVs onto the electric grid. If EVs mostly charge during times of low grid utilization, they can help maximize the use of grid resources and produce significant cost savings for consumers. The deployment of vehicle-to-grid or vehicle-to-building technologies that allow EVs to act as grid storage could enhance the benefits of EVs. This Plan calls for proactive management of EV charging to maximize the benefits of EV adoption and minimize the costs to all consumers.

TRANSPORTATION POLLUTION AND ENVIRONMENTAL JUSTICE

Pollution from cars and trucks impact the health of all Massachusetts residents, but some communities face a greater burden from transportation pollution than others. People living in communities near highways and in dense urban areas are exposed to higher levels of pollution from vehicle traffic. Communities near important freight corridors, ports, warehouses, and distribution centers face higher levels of particulate matter and nitrous oxide emissions from diesel vehicles used in commercial freight operations. Specific communities—such as those surrounding Logan Airport and seaport communities with substantial truck traffic and diesel-dependent activity such as Chelsea, Everett, and New Bedford—are known hot spots for transportation emissions. Overall, analysis by the Union of Concerned Scientists demonstrates that communities of color face significantly more pollution from transportation than predominantly white communities.[21]

The most effective strategy to reduce the harmful health impacts of transportation pollution on EJ communities is to electrify diesel vehicles operating in EJ communities. Studies have shown that among a range of potential clean transportation investments, electrification of diesel vehicles, such as delivery trucks and school buses, has the greatest potential to improve air quality. Last-mile delivery vehicles represent an appropriate target for electrification, as these vehicles travel on relatively short and predictable routes and operate within residential communities. Transit and school buses also will be a

[21] Pinto de Moura, Maria Cecilia, David Reichmuth, "Inequitable Exposure to Air Pollution from Vehicles in the Northeast and Mid-Atlantic," Union of Concerned Scientists, 2019. (Can be downloaded at https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles).

top priority electrification target, and work is currently underway in both of those areas. Acknowledging the historical burden on EJ populations, clean transportation policies will provide additional incentives for electrifying public and private diesel vehicles operating in EJ communities, in addition to technical and infrastructure support.

Continually improving public transit is on the state's policy agenda, particularly because many transit services are a critical lifeline for thousands of low- and moderate-income Massachusetts residents. To maximize the benefits of public transit , including climate benefits, Massachusetts municipalities need to allow for the building of more housing near transit. Massachusetts' Housing Choice Initiative and the new multifamily zoning requirements for MBTA Communities are beginning the process of working with local government to promote housing near transit.

In addition, the Commonwealth will work to reform the existing EV incentive programs to make them more accessible to low- and moderate-income residents. The programs already in place will transition to providing incentives at the point of sale, an increased incentive for low- and moderate-income drivers, and e-bike incentives. Through its existing Accelerating Clean Transportation for All program (ACT4All) program, MassCEC will continue to provide grant opportunities for clean transportation with community partners operating in EJ communities.

Effective management of EV charging has raised important equity and environmental justice considerations. If EVs charge during peak electricity usage hours, that could increase the need to expand and build the electric distribution system. Producing electricity during peak periods also could increase the operation of "peaking plants," which tend to have high emission rates. Responsible grid management is thus an important component of the Plan's EV strategy. As a part of the electrification of transportation and building heat, electric distribution utilities will need to develop and implement new electricity rate designs and install advanced metering infrastructure to encourage EVs to charge during non-peak usage periods.

Below are more detailed descriptions of Massachusetts' Clean Transportation Strategies to achieve the transportation sector sublimits in 2025 and 2030.

STRATEGY T1: PROMOTE ALTERNATIVES TO PERSONAL VEHICLE TRAVEL

Massachusetts will look to achieve sustained reductions in VMT below baseline projections, as Massachusetts' economy and population continue to grow.

In many Massachusetts communities, daily use of a personal vehicle is an essential part of life. Development patterns and zoning regulations that favor single family homes and single use neighborhoods in which destinations are far apart from each other mean that many residents have few practical options other than a car to get around. Transportation infrastructure that provides little protection for bikes and pedestrians can make it feel dangerous to walk or to bike. At the same time, restrictions on growth in communities with good walking, biking, and transit infrastructure increasingly make these neighborhoods prohibitively expensive for many people.

Changing these facts on the ground will require a transformation in the way communities think about land use, urban planning, housing, and transportation. It will require close coordination between state agencies, federal authorities, and local government. It will require local government to make changes in

the way it uses land and public space. It also will require employers to think about how they can contribute to reducing unnecessary travel.

The IIJA provides the Commonwealth with an unprecedented opportunity to invest in its transportation systems. Thanks to the IIJA, Massachusetts will receive over $4 billion in transportation formula funding—funding provided for specific uses based on formulas developed by Congress—over the next five years.[22] While much of this funding is committed to certain types of transportation investments, it does provide opportunities to modify existing infrastructure to better support multimodal and non-vehicle mobility. This opportunity provides new federal money for the Commonwealth to expand its network of EV chargers. In addition, the IIJA provides the opportunity for Massachusetts to apply for competitive grants aimed at a wide variety of mobility and community needs. Federal guidelines indicate that transportation projects with the potential to reduce emissions, along with other criteria, will be prioritized for grant funding. This funding provides the Commonwealth with an opportunity to direct funding toward the projects that have the best potential to reduce emissions.

Some stakeholders have requested significant investments in electrifying MBTA commuter rail lines. While in the long-term, having a zero-emitting commuter rail system will be a part of the overall decarbonization solutions for the Commonwealth, for this 2025/2030 CECP, the costs associated with electrifying commuter rail have not yet been fine-tuned and incorporated into the updated 2050 Roadmap Study. Future work will be needed to develop the detailed costs and benefits of electrifying the commuter rail system.

Encourage Multifamily Zoning Near Transit Stations

One of the most effective strategies to increase access to and use of public transportation is to build housing near public transportation stations. Currently, many cities and towns that have easy access to public transportation have zoning requirements that either prohibit new multifamily housing construction or make new housing development subject to a lengthy and unpredictable permitting process.

A recent change to the state zoning law requires 175 communities within the MBTA service area to have at least one zoning district of reasonable size where multifamily uses are allowed as of right. These multifamily zoning districts must be located within a half mile of a subway station, commuter rail station, ferry station or bus station, where applicable. This new requirement is an opportunity for the Commonwealth to create capacity for tens of thousands of new housing units near public transit, with the potential to reduce housing costs, reduce congestion on our roads, and ultimately reduce transportation emissions. The Department of Housing and Community Development (DHCD), in consultation with MBTA and MassDOT, will issue final guidelines this year advising communities on how to comply with this new requirement. DHCD and other housing agencies expect to provide significant technical assistance to cities and towns to create these new multifamily zoning districts.

In addition to this initiative, various state agencies will continue to support Massachusetts cities and towns to address some of the additional barriers to smart growth and transit-oriented development, such as excessive parking requirements, minimum lot size requirements, set-asides, and limits on

[22] Not all of this funding is new funding. Most of the new funding is for fixing existing infrastructure.

accessory dwelling units, particularly as these rules limit housing production near public transit. The Commonwealth will continue to provide a Smart Growth / Smart Energy Toolkit that provides local government with technical support in achieving smart growth goals.[23] A package of zoning reforms proposed by the Governor and signed into law in January 2021 has created a more predictable process at the local level for the adoption of housing best practices. By reducing the threshold of votes needed from a supermajority to a simple majority for certain zoning measures that promote housing production, the state has empowered local governments to approve housing-supportive zoning and development that encourages increased density and smart land use practices.

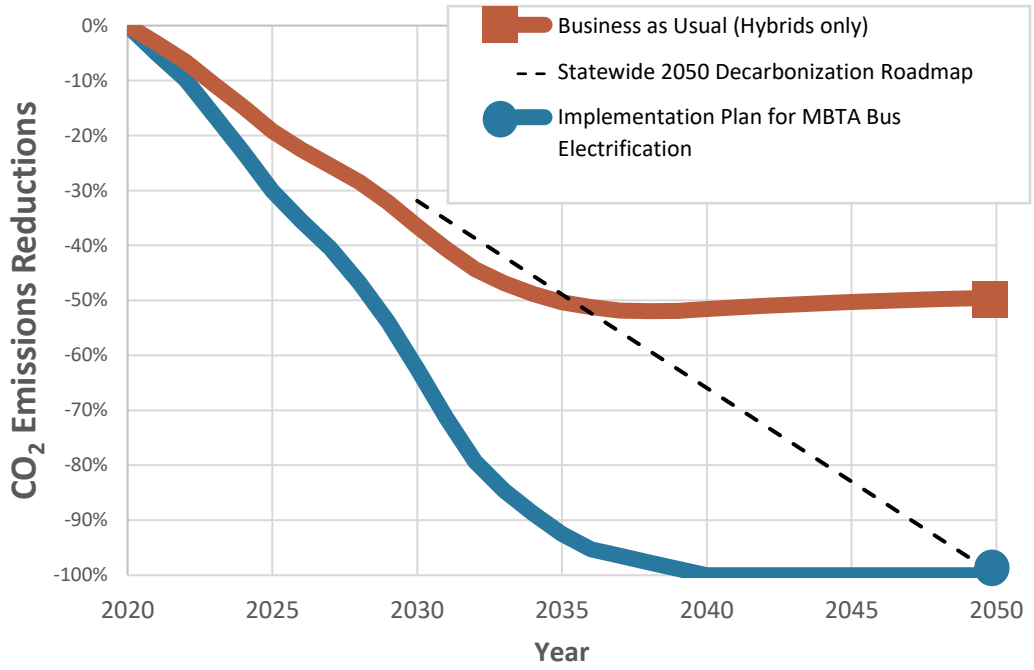
Support and Execute the MBTA Bus Modernization Program

The MBTA is steadfastly working to convert its entire bus fleet to battery electric buses by 2040—one of the most aggressive public bus electrification timelines in the United States. This bold effort aligns with the MBTA's longstanding goal of providing reliable, equitable, and clean bus transportation for eastern Massachusetts. The MBTA Bus Modernization program includes purchasing new and cleaner buses, building multiple new maintenance facilities equipped for battery electric buses, and modifying existing bus routes and schedules to better reflect the needs of bus riders. While the MBTA has programmed funding for the first phases of this important work, additional multi-agency partnerships across both state and local government and support with funding and land acquisition will be needed to keep the overall program on schedule and to help the MBTA to meet its 2040 goal for decarbonizing its bus fleet.

Under the Bus Modernization Program, the MBTA will deploy battery electric buses as it modernizes its bus maintenance facilities to improve working conditions, expand capacity, and incorporate electric charging infrastructure. As new facilities come online, the MBTA will fill them with battery electric buses—starting with a retrofit of the North Cambridge Carhouse in 2023 (35 buses), a new facility in Quincy in 2024 (45 electric buses to start, with capacity for 120), and a new facility in Boston along the Arborway in 2027 (200 buses). Provided that the necessary funding and land for the Arborway project is in place to support a completion in 2027, approximately one-third of the MBTA bus fleet will be electric by 2028. By 2030, more than half of the fleet will be electric, with the completion of additional facilities at Wellington and in Lynn; again provided that funding and land are available. The remaining facilities are targeted for completion every 2-3 years (see Figure 4.1 below).

[23] https://www.mass.gov/service-details/re59r09-smart-growth-smart-energy.

Figure 4.1. Projected Emissions Reductions based on MBTA Bus Electrification Plan



To replace the oldest diesel buses and support reliable service for bus riders during its transition to an all-electric bus fleet, the MBTA is currently in the process of procuring both efficient hybrid buses and battery electric buses. This will allow the MBTA to incrementally bring electric buses into the fleet, in concert with the completion of new electrified maintenance facilities, without disrupting service for riders. All these buses will be cleaner and quieter than the buses they replace. In particular, the new hybrid buses will allow for geofenced 'green zones.' These defined geographic areas are activated by GPS and can be targeted to eliminate engine use—and thus emissions—near schools, parks, hospitals, and EJ communities (as potential examples).

The ongoing battery electric bus procurement supports the transition to a full electric fleet by 2040. The MBTA anticipates selecting a bus manufacturer by December 2022, with new BEVs then placed into service for MBTA-bus passengers in 2023.

Throughout the 2022-2028 period, the MBTA also will be implementing changes to its bus routes and frequencies that will help to better meet demand, making bus transit a better mobility choice for more people. Currently under development, the plan will create more all-day service, more service in busy neighborhoods, and new connections to more places. In the proposed new network, which is the product of a multiple-year public engagement process, the MBTA will double the amount of high-frequency bus service offered across the MBTA network. Nearly 300,000 more people will have access to 7-day-a week, 15 minutes or better, all-day service. Seventy percent of residents of color within MBTA service territories will have access to high-frequency service, and half of all low-income households will have access to high-frequency service. The proposed new network also will increase weekend service with 36% more service on Saturdays and double the amount of service on Sundays.

The MBTA Bus Modernization Program will meaningfully improve bus transportation for the MBTA region, carrying more people on cleaner buses based on a more convenient network and schedule and supported by modern and efficient maintenance facilities.

Increase Support for the MassDOT Complete and Shared Streets Programs

Through MassDOT's Complete Streets and Shared Streets and Spaces municipal grant programs, Massachusetts cities and towns have invested over $100 million in transportation projects that encourage active transportation. These funds are being used to create dedicated lanes for bikes or buses, better sidewalks, better accessibility for people with disabilities, better community places and spaces, and street designs that promote pedestrian safety. These projects make communities safer by reducing vehicle speeds and providing cyclists and pedestrians with protection from cars. The safety improvements help increase walking and biking, reduce the use of vehicles for local and short-distance travels, reduce emissions, and make for healthier public spaces. Similarly, MassDOT partners with EEA, the Department of Conservation and Recreation (DCR), and municipalities to incrementally build a shared use path/trail network for the Commonwealth that decreases dependency on driving and increases opportunities for people to walk and bike. The Massachusetts trail network currently includes 687 miles, with 308 miles remaining to be built.

With additional funding, Massachusetts could expand and accelerate the work of all of these programs, to serve more communities and provide more and safer alternatives to private cars. These programs are only one way in which Massachusetts is bringing a multimodal mentality to all transportation investments, prioritizing transportation infrastructure projects that will provide benefits to all road users over those that promote the exclusive use of automobiles.

Work with Employers to Reduce Single Occupancy Commutes

MassDEP currently implements the Massachusetts Rideshare Regulation (310 CMR 7.16), which requires certain facilities to implement and maintain measures designed to achieve a non-binding goal of reducing single-occupancy vehicle (SOV) commutes by 25% and to produce annual reports detailing steps taken to achieve that goal. Broadening the scope of this regulation or utilizing a complementary approach can help to reduce traffic congestion, air pollution, and GHG emissions. As part of a holistic update of the Commonwealth's commuter-focused policies under this 2025/2030 CECP, MassDEP will evaluate the role telework may play in the future of the Commonwealth's economy and its GHG and VMT reduction strategies.

Launch an E-bike Incentive Program

Electric bikes represent a relatively new technology with the potential to expand active mobility options for some users. By providing users with the additional boost of an electric motor, e-bikes are a fun, zero-emission ride that can go longer distances and tow more cargo than conventional bicycles. Studies confirm that e-bikes can potentially replace car trips for some commuters. Making the most of this technology will require both incentives and continued improved bike infrastructure to ensure the safety of e-bike users and pedestrians. EEA and MassCEC are currently funding projects to promote community e-bikes as part of grant projects in Worcester, the Pioneer Valley, the Berkshires, and as a last-mile delivery solution in Allston. EEA will look to complement these investments with a statewide e-bike incentive. At the same time EEA, MassDOT, and DCR will work with the legislature to update the

underlying statute, and the Executive branch will develop e-bike regulations that promote safety for all road users.

STRATEGY T2: IMPLEMENT COORDINATED ADVANCED CLEAN VEHICLE EMISSIONS AND SALES STANDARDS

State governments are generally precluded by federal law from setting their own vehicle emissions standards. However, under Section 209 of the Clean Air Act, California and the California Air Resources Board (CARB) have unique authority to set vehicle emissions standards independent of the federal government. Under Section 177 of the Clean Air Act, Massachusetts and other participating states can choose to adopt the California vehicle emissions standards. Existing Massachusetts law requires the Commonwealth to adopt the California standard if it is more protective of the public health than the federal standard.

Picture 7. EV Plugged into Electric Charger

The Advanced Clean Cars program, promulgated by MassDEP (and CARB) in 2012 and covering passenger vehicles manufactured between 2012 and 2025, required auto manufacturers to build and sell an increasing number of ZEVs in Massachusetts and other participating states. This program has been one of the primary drivers of vehicle electrification to date. California is now moving forward with post-2025 regulations that would for the first time set a pathway for 100% of all passenger vehicle sales to be zero-emission, as well as new sales requirements on medium- and heavy-duty vehicles. The Commonwealth is in the process of following suit.

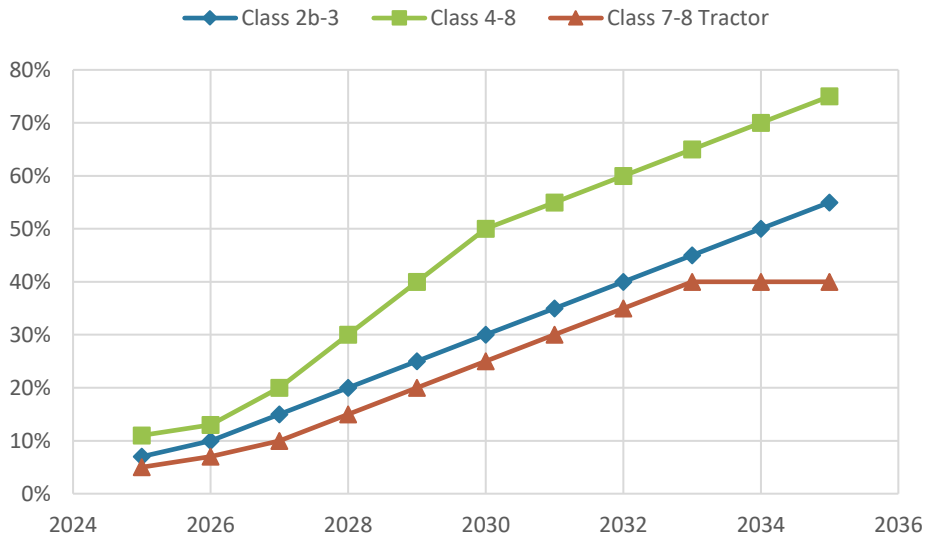
Advanced Clean Cars II

Pursuant to Governor Newsom's Executive Order in 2020, California is currently in the process of promulgating a new Advanced Clean Cars II regulation that will require continued growth in zero-emission passenger vehicle sales, until ZEV sales reach 100% of all passenger vehicle sales by 2035. Massachusetts was the first participating state to endorse this goal and will promulgate the next round of regulation by the end of 2022.

Advanced Clean Trucks

In addition to the Advanced Clean Cars program, in 2021, CARB promulgated the Advanced Clean Trucks (ACT) rule, which requires an increasing percentage of zero-emission medium and heavy-duty vehicles, with different vehicle classes having different ZEV sales requirements (Figure 4.2). MassDEP adopted this rule in 2021 as required by statute. The ACT rule will begin to impose mandatory sales requirements on truck and bus manufacturers beginning in model year 2025.

Figure 4.2. Advanced Clean Truck Rule with ZEV Sales Requirements



STRATEGY T3: EXPAND ELECTRIC VEHICLE INCENTIVES

While vehicle emissions standards ensure that manufacturers keep producing more ZEVs, additional support will be necessary to make sure that Massachusetts consumers can take advantage of the new technologies. Massachusetts has offered rebates for EV purchases through the MOR-EV program since June of 2014. Since then, over 24,000 Massachusetts residents have received a rebate for the purchase of an EV. The current rebate value is $2,500 for a BEV and $1,500 for a plug-in hybrid vehicle.

Achieving the 2025 and 2030 emissions limits in transportation will require EVs to reach a much broader range of consumers, moving beyond early adopters and into the mainstream market. To accelerate adoption, Massachusetts will reform the current EV incentive programs to increase accessibility. One key reform will be to make incentives available to consumers at the dealership when they purchase the vehicle, rather than waiting for their rebate after the purchase. Massachusetts will target incentives toward low- and moderate-income purchasers and less expensive vehicle models, where incentive dollars can impact more consumer decisions.

Rebates for all EV consumers are not intended to be a permanent feature of Massachusetts policy. Most industry analysts predict that decreasing battery costs and increasing sales volumes, combined with increasingly stringent vehicle standards, will allow BEVs to achieve price parity with internal combustion vehicles without an incentive in this decade, at least for passenger vehicles. Moreover, as EV sales increase, the cost of providing an incentive for every EV purchase would become unsustainable. Thus, the reforms we make today will help us transition to a program of targeted assistance in the future.

Implement Reforms to MOR-EV

Consistent with the recommendations of Massachusetts Department of Energy Resources' (DOER's) third-party independent MOR-EV Cost-Effectiveness Study, EEA will implement reforms to make the

state program more equitable and cost-effective.[24] The Commonwealth will look to establish a point of sale rebate, as well as a new additional incentive for low- and moderate-income residents and high mileage drivers.

Picture 8. Intelligent Labor and Moving Company EV Truck

Maintain MOR-EV Trucks

Medium- and heavy-duty vehicles represent less than 10% of the vehicles on the road, but they are responsible for about 40% of total GHG emissions.[25] Massachusetts launched its first incentive for electric medium- and heavy-duty vehicles in 2020, MOR-EV Trucks, which provides purchase incentives for medium- and heavy-duty vehicles in Massachusetts, from Class 2b trucks to Class 8 tractor trailers and buses. The Commonwealth will maintain incentives as long as they help to facilitate the growth of this market.

STRATEGY T4: ACCELERATE ELECTRIFICATION IN FLEETS WITH CRITICAL EQUITY AND PUBLIC HEALTH IMPLICATIONS

As part of its commitment to an equitable transition to clean transportation, the Commonwealth will accelerate electrification of public and private fleets that could help either expand access to electric transportation or address emissions in communities that are heavily impacted by transportation pollution.

Accelerate Electrification of Vehicles for Hire

Vehicles for hire represent a unique opportunity to accelerate EV adoption. The cars that are driven in ridehailing, carsharing, and taxi fleets are high-mileage, public-facing, and are driven disproportionately by low-income residents. Electrification of vehicles for hire can be an opportunity to increase utilization of charging infrastructure in communities with low-income and EJ population, paving the way for broader adoption. The Commonwealth will implement a program to electrify this subsector, including expanded incentives, support for infrastructure, and outreach and education. The Commonwealth will consider how to use and access incentives at Logan Airport; about half of all taxi and a large proportion of ridehailing trips start and end at Logan Airport. Thus, providing incentives for electrifying ridehailing trips that start or end at Logan Airport can help spur adoption of EV technology for vehicles for hire.

Accelerate Electrification of Delivery Trucks

As discussed above, long-term increases in consumer demand for short-haul deliveries and growing warehouse distribution have led to increasing GHG emissions, noise pollution, urban on-road and curbside congestion, and health impact concerns for local communities, the burdens of which

[24] Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Cost-Effectiveness Study: 2014-2020 Program Results Summary, Independent Study Prepared by Synapse Energy Economics for the Massachusetts Department of Energy Resources, March 2, 2022. (Can be accessed at https://www.mass.gov/doc/zev-commission-april-15-2022-mor-ev-cost-effectiveness-study-32922/download.)
[25] ICCT, available at https://theicct.org/publication/transitioning-to-zero-emission-heavy-duty-freight-vehicles/

disproportionately fall on low-income communities and communities of color. Further, e-commerce sales have increased by 34% since the start of the COVID-19 pandemic. Over 40% of restaurants have added delivery options to their services and 21% of consumers have tried using a delivery service for their groceries for the first time, all of which are trends that are expected to continue beyond the pandemic. To adapt to these changes in the market while achieving emissions limits in this sector, MassCEC will continue to develop programs that provide incentives to businesses to decrease emissions from high-mileage, low-radius fleets. Alternatives to traditional fleet expansion include vehicle conversion to zero-emission technologies, duty cycle management, route planning, zoning, and idle reduction.

Accelerate Electrification of School Buses

Diesel school buses expose children to emissions at pickup, at drop-off, and in the cabin of the vehicle, exacerbating conditions such as asthma and potentially impacting student performance. School buses represent a promising opportunity for electrification, as they tend to travel along predictable routes that are within the range of modern electric bus technology. The large battery in a school bus combined with the fact that school buses are often not in service during the middle of the day or the evening means that electric school buses may have a strong role to play as backup electricity storage during hours of peak electricity demand. Further, federal resources in the IIJA provide immediate opportunities for rapid electrification of school buses. Through the Accelerating Clean Transportation: School Bus program, MassCEC will partner with school districts and school bus fleet managers. MassCEC will provide infrastructure and technical support to ensure that Massachusetts schools are well prepared to take advantage of federal funds to support rapid electrification of school bus fleets.

Provide Grants to Community Organizations to Reduce Transportation Emissions

Through the ACT4All program, EEA and MassCEC are directly partnering with community organizations to support efforts to reduce transportation emissions with a focus on expanding mobility and improving air quality in EJ communities and diversifying the EV consumer base. This program provides community leaders with the opportunity to generate their own ideas and creative solutions for how to address emissions and transportation challenges. The first iteration of this program generated a range of project ideas, such a proposal to use e-cargo bikes to provide last-mile delivery services in Allston, an education and outreach campaign oriented toward immigrant communities in Quincy, and a program to provide community access to e-bikes in the Pioneer Valley. EEA and MassCEC will continue to partner with communities and provide additional opportunities to fund clean transportation projects.

STRATEGY T5: BUILD ELECTRIC VEHICLE CHARGING STATIONS AND ENCOURAGE SMART CHARGING

The need for charging infrastructure remains one of the most important components of mainstreaming the use of EVs. Most EV charging will occur at home. Installing charging infrastructure at homes can be an added cost and complication for EV consumers, while tenants and people living in large apartment buildings do not have access to home charging. Public fast charging stations are critical to support long-distance trips and may play an important role supporting charging in community locations for some users. Workplace charging could be an excellent choice for some users particularly where home-charging is not immediately available.

No matter where one charges, managing the impact of EV charging on the electricity grid can be one of the system-wide issues that may affect the costs and benefits of EV adoption. Considering the impact that EV charging has on the electricity grid, encouraging charging during off-peak periods will be critically important. While the major electric distribution companies in Massachusetts have developed active demand response programs that help encourage customers to manage their charging, these programs remain small and underutilized. The Commonwealth, with the electric utilities, will need to take additional steps to encourage customers to enroll in managed charging programs, ensuring that the state's electric infrastructure continues to be used efficiently.

Build Out Fast Charging Along Highway Corridors

The IIJA provides approximately $60 million over five years to Massachusetts to fund fast charging stations along major highway corridors. MassDOT and EEA are working together to develop and implement plans to support the build out of these fast-charging stations. The IIJA also provides the Commonwealth with competitive grant funding opportunities to support community-based charging locations.

Support Direct Current Fast Charging Deployment

Massachusetts encourages private sector investments in fast charging infrastructure to reduce the burden on overall public resources to support electrification of private vehicles. This will in turn encourage EV adoption because seeing more public charging capabilities will reduce "range anxiety" for EV drivers. The Commonwealth will explore the potential of competitive grants to demonstrate innovative charging system infrastructure systems and business models. Beyond charging station ownership and operation innovation, EEA and DOER will leverage pairing solar and/or storage with charging stations as a method to manage financial and grid impacts.

Require Make-Ready Charging for All New Buildings

EEA and DOER will develop a model building code for municipalities that requires make-ready charging in all new commercial and residential buildings. In particular, the new stretch building code proposal will require new 1-4 unit homes with off-street parking to provide at least 1 EV-ready parking space, and will require at least 10% of parking spaces in large apartment buildings to be EV-ready. The stretch code will also require at least 10% of parking spaces in new commercial parking lots to be EV-ready. This effort anticipates that the private sector will continue to install charging infrastructure and respond to consumer demand following this first phase of deployment.

Support Residential Smart Charging

Most EVs charge at home, which is where EV infrastructure will be the cheapest to install and where load control will be the easiest. The Commonwealth is currently evaluating options and programs proposed by the electric distribution companies to make installing home charging stations as affordable and convenient as possible for customers who are willing to sign up for managed charging. In addition,

the state or electric utilities' program will help support building charging stations in apartment buildings and thereby support, in some cases, tenants who wish to charge at home.

STRATEGY T6: ENGAGE CONSUMERS AND FACILITATE MARKETS

Provide Technical Support for Fleet Operators Considering Transition to Electric Vehicles

For large fleet operators, such as commercial delivery trucks, the decision to transition a vehicle fleet to EVs is complicated, requiring considerations about technology capacity, infrastructure, route design, cost, and financing. MassCEC has developed a fleet advisory service program that can help inform fleet operators as they transition to EVs. It will complement this fleet advisory service program with direct infrastructure support to ensure that the transition to EVs is cost-effective for public and commercial fleets.

Outreach and Customer Support

Potential EV buyers for light-duty vehicles have many questions about the technology, including how to charge, where to charge, how to deal with charging station costs, how to install a station, where to find public charging stations, and other topics. MassCEC will continue to partner with and provide support for the organizations that directly conduct outreach to consumer and technical support to help with the EV transition. Promotional efforts, such as ride and drive events, recognition ceremonies, and creating accessible public information is essential to advance this transition. MassCEC will aim to assist outreach to all purchase decision-makers, particularly focusing on low- and moderate-income consumers.

Support Building a Workforce for EVs

Substantial zero-carbon transportation technologies and supporting infrastructure are needed to meet the state's decarbonization and GHG emissions sublimits. MassCEC is conducting a workforce needs assessment to support the 2030 targeted technology rollout. One anticipated outcome of this study will be a framework for workforce development needs that will help integrate lessons learned into follow-on programming to train and re-train workers in the growing clean transportation sectors.

Investigate and Pilot Options for Hard to Electrify Segments

Rail, on-road heavy or long-distance freight, and port and marine vehicles are difficult and/or very expensive to electrify. Massachusetts will develop strategies to decarbonize these transportation modes and pilot technology approaches as appropriate. In particular, advanced synthetic fuels and hydrogen may be viable paths as discussed in the 2050 Roadmap Study. The Commonwealth has recently committed to joining a regional consortium to explore hydrogen buildout for these and other applications.[26]

Support Short-Haul Aviation

Electrified short-haul aviation equipment options are nearing commercial readiness. Electrified Aviation (EA) infrastructure, which includes charging stations and energy storage, will be necessary to support

[26] https://www.nyserda.ny.gov/About/Newsroom/2022-Announcements/2022-03-24-Governor-Hochul-Announces-Multi-State-Agreement-on-Hydrogen.

the growth of this segment. Early adopters are most likely to include regional airports across the state, most notably on the Cape and the Islands. Targeted investment in demonstration projects, particularly EA charging infrastructure will help accelerate adoption and lead to private sector investment in this important low-carbon transportation modality and establish Massachusetts leadership in this segment.

CHAPTER 5: TRANSFORMING OUR BUILDINGS

5.1 SECTOR OVERVIEW

The Buildings sector in Massachusetts is large and diverse, with over two million individual buildings spanning a wide range of construction types, occupancy needs, ownership, and equipment. While the energy needs for buildings in the Commonwealth differ widely based on age, configuration, size, and use, space heating usually drives a building's energy demand. Water heating, cooking, and electrical appliances account for the remaining building energy usage. About half of all residential households in Massachusetts use pipeline gas for space heating, just under a third use delivered petroleum products (fuel oil or propane), and about 15% use electricity for electric resistance heating and air-source or ground-source heat pumps. About three-quarters of commercial square footage in Massachusetts is heated with natural gas, with petroleum, electricity, and district steam systems comprising the remainder. Lights, air conditioners, computers, appliances, and other "plug loads" are mostly powered by electricity and up to approximately three-quarters of Massachusetts' total electricity demand.

As an accounting convention adopted by the Commonwealth in 2009, the GHG emissions from the Buildings sector covers 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. As further explained in Chapter 6, the GHG emissions associated with electric power generation have decreased by half since 1990 and are on track to further decline through 2030 to nearly zero by 2050. 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.

GHG emissions from fuel combustion in residential and commercial buildings have generally trended downward since 1990. Energy efficiency measures, including increasing insulation of building envelope and installing high-efficiency boilers and furnaces, have helped decrease fossil fuel consumption and associated GHG emissions over the last few decades. At the same time, historically low natural gas prices and volatile petroleum prices have driven consumers to switch from using fuel oil to natural gas, which emits less carbon emissions per unit of heat provided than oil. However, incrementally reducing the average energy demand and GHG emissions per square foot of our homes and offices will not be enough to reach the Commonwealth's economy-wide GHG emissions limits. Instead, achieving deep decarbonization goals in homes and other buildings will ultimately require burning less fossil fuel for space and water heating. This decarbonization work comes amidst great pressures on the built environment of Massachusetts. Driven by robust economic and population growth, the Commonwealth's total built space is increasing, leading to increasing energy demands and emissions. Housing costs are also rising as new housing development has trailed behind burgeoning demand. In addition, global energy costs are rising, disproportionately affecting low- and moderate- income citizens. Thus, policies directed at reducing total energy use and transitioning to clean energy resources in the Buildings sector must also focus on protecting those most vulnerable to potential cost increases while reducing GHG emissions.

5.2 ACHIEVING 28% REDUCTION IN 2025 AND 47% IN 2030 FOR BUILDING HEAT

To achieve a net zero future, the 2050 Roadmap Study focused on the widespread deployment of envelope efficiency improvements and electric heat pump installations. While the technologies to use biofuels, clean biogas, and green hydrogen may be available, using those resources to heat our homes and businesses will require developing new supply chains, with significant uncertainties around the availability and costs of the resources. In addition, it is unclear how developing clean natural gas and hydrogen at scale would affect land use and global food and commodity prices. The Commonwealth's dominant building decarbonization strategy continues to be maximizing energy efficiency and electrifying thermal demands.

The best way to increase energy efficiency in buildings is through implementation of standards that drive investment in energy efficiency technologies. Updated building codes and the municipal opt-in net zero energy codes will set high-efficiency benchmarks for new construction, including Passivehouse standards for new multifamily buildings (see call-out). For existing buildings, the new Mass Save Three-Year Energy Efficiency Plans include substantial incentives for building owners and operators to invest in measures that tighten building envelopes. These investments will result in reduced energy footprints for both heating and cooling, saving utility costs and reducing greenhouse gas emissions.

While there is a focus on reducing energy demand of buildings, many technologies allow Massachusetts consumers to transition away from fossil fuels as a source of energy. In particular, heat pump systems can accommodate a wide range of building system needs with much greater efficiency than combustion-based heating systems, reducing a building's total energy use. Cold climate air-source heat pumps designed to operate effectively below 5° F entered the New England market a decade ago. Throughout the region, especially in Vermont and Maine, heat pumps are commonly installed as primary space heating without backup. These heat pumps can also be sized to provide efficient air conditioning and reduce space heating costs. Heat pumps, specifically ductless heat pumps, offer the most promising pathway to provide cooling in existing buildings with radiators. Ductless mini-split heat pumps can provide space cooling with less invasive installations compared to major renovations to install central air conditioning with air ducts. As the climate warms and access to space cooling becomes a necessity rather than a luxury in Massachusetts, heat pumps are poised to experience significant market growth. However, the installation of any new heating, ventilation, and air conditioning (HVAC) system generally requires significant up-front costs, especially if the installation requires major retrofits to heat delivery systems. Many of the policies in this chapter are therefore dedicated to helping consumers with retrofits and ensuring that current policies that assist consumers in such renovations are aligned with the Commonwealth's goals for electrification and energy efficiency. Providing all households with access to these technologies, especially low-income households and EJ populations, is crucial to meeting the 2025 and 2030 targets.

PASSIVEHOUSE STANDARDS

Passivehouse, a proven, highly efficient building design and construction standard, first emerged in Germany in the 1990s and is now the "go to" building and home efficiency solution across Europe, North America, and Asia. As of 2020, over 25 million square feet of new construction and renovations have been built to Passivehouse standards in at least 45 countries.

Passivehouse buildings and homes typically have 90% lower heating loads than conventional construction. Achieving this level of efficiency relies on six key principles:

1. Low envelope air infiltration
2. High quality windows and doors
3. Thermal-bridge free construction
4. Ventilation energy recovery
5. Productive use of solar gains during heating season
6. Management of excessive solar gains in cooling season

These principles result in buildings and homes that have much lower energy use intensity and greenhouse gas footprints. They also enable the switchover to clean heating systems at lower costs.

In addition to decarbonization, the quality envelope and extremely low air infiltration mean that Passivehouse buildings and homes can stay warm (in the winter) and cool (in the summer) for extended periods of time, even if they lose power. Quality windows mean that occupants can enjoy all the space inside with no drafts or cold spots, even if sitting immediately adjacent to a window, while quality envelopes dramatically reduce exterior noise. Finally, controlled ventilation to all spaces, including bedrooms, provides occupants with fresh air year-round, resulting in measurable health benefits.

Picture 9. Passivehouse Multifamily Building

The Commission on Clean Heat has been working since the beginning of 2022 to provide recommendations to the Baker-Polito Administration on the specific policies that would support the reduction of GHG emissions from building heat. This chapter includes many of the Commission's *preliminary* recommendations to inform the policies and programs presented as part of this 2025/2030 CECP. The final recommendations will be provided by the Commission on Clean Heat at the end of 2022, and may help further refine the Plan's strategies.

The Commission on Clean Heat has been discussing the high-level policy objectives, which are summarized in the paragraphs below.

To ensure broad access to clean heat technologies, such as cold climate air-source heat pumps, the Commonwealth needs to advance a public service campaign to educate consumers about the state's long-term energy efficiency and electrification efforts in the building space. Increasing public awareness of the benefits—including how the technologies contribute to meeting the Commonwealth's decarbonization goals—will support and create demand for clean buildings and heating technologies. Specifically, **consumer engagement initiatives** are needed to help residents understand the available options and the impacts of each purchase and operational decision. Such engagement can streamline decision-making and implementation, as well as facilitate choices that deliver financial savings and improved quality of life. When done effectively, this outreach can increase transparency, encourage participation, and improve consumer sentiment. In addition, the Commonwealth will explore new **financing and investment initiatives** to provide up-front capital for building retrofit projects that do not have existing financing options. Increasing financing options will include finding ways to leverage private capital to support a growing clean heat industry. **Regulatory and policy structures** must support decarbonization, including providing utilities and municipalities with guidance to help manage the transition, decrease total cost, and limit impacts on energy prices.

Beyond supporting the deployment of clean heating technologies and energy efficiency alongside other capital improvements to buildings, the policies should drive several additional objectives. Leveraging Massachusetts' position as a leader in **technology and innovation**, pilot and demonstration projects with academic and private partners can advance new solutions, address outstanding technology gaps, and establish clear and comprehensive best practices for building decarbonization. At the same time, **workforce development** will expand educational and training opportunities to foster a robust workforce, including expanding access to well-paying jobs for underrepresented populations. **Industry support** initiatives will help those who currently work in other sectors develop skills to work for companies expanding into advanced building technologies. Great care must be placed on ensuring an equitable distribution of opportunities and benefits associated with decarbonizing buildings as it represents an engine for new economic growth in the Commonwealth.

Picture 10. Solar Installation Training

In addition to equipment purchase decisions made by residents and businesses, investments made by natural gas utilities to upgrade natural gas distribution assets—gas pipelines, mains, service pipes, compressor stations, and meters—often last for many decades and can become a growing obligation for those who continue to use natural gas. While future technological breakthroughs may alter the trajectory for renewable fuels, the Commonwealth's plan for building decarbonization should include strategies to mitigate the risks of locking in additional investments and costs of pipeline systems that must eventually be paid for by either ratepayers or gas utilities' shareholders.

Decarbonizing the Buildings sector will require careful, aligned action from a wide variety of perspectives across the state—HVAC equipment suppliers and contractors, homeowners and building

operators, private markets, and public authorities. Careful policy and program designs must pay attention to increasing benefits and value to those most vulnerable populations.

THE COMMISSION ON CLEAN HEAT

To support meeting the building sublimits, Governor Baker's Executive Order No. 596 formally established the Commission on Clean Heat to advise the Administration on a framework for long-term GHG emissions reductions from heating fuels. The Executive Order also designates an Interagency Building Decarbonization Task Force comprised of representatives from key state agencies to assist the Commission in its deliberations. This process is ongoing and will continue to develop recommendations for regulations and other policies through the end of 2022.

The Commission's deliberations and preliminary recommendations also highlight the importance of supporting programs and policies that can help the market to operationalize and deliver clean heat solutions as well as drive forward goals around equity and environmental justice. To facilitate deeper deliberation, the Commission divided into four working groups around key topic areas:

- **Institutions and Financing**: recommendations to align key institutions across the Commonwealth towards meeting decarbonization goals and ensure approaches are effectively and equitably resourced.
- **Public Perception and Community Engagement**: recommendations to support effective communications and community engagement to shape public perception and drive impactful and equitable solutions.
- **Technology and Workforce Development**: recommendations to support the development of a supply chain and workforce capable of delivering technology solutions affordably and at scale to the Commonwealth's diverse building stock.
- **Regulatory and Policy Frameworks**: recommendations to address immediate gaps in existing regulations, codes, policies, programs, and incentives and/or develop new policies or programs to rapidly scale decarbonization.

Based on the four working groups' initial priorities and discussions, the Commission developed a list of preliminary recommendations. Further development of these recommendations, along with a framework for capping the emissions from heating, will be the focus of the Commission's work through the end of 2022. Many of the Commission's recommendations are fully consistent with prior feedback that the Commonwealth has received from the GWSA Implementation Advisory Committee and other key stakeholders. Thus, many of the policies discussed throughout this chapter reflect priorities that the Commission will continue to develop, with assistance from the Task Force, into a detailed portfolio of policies and a timeline of recommended key actions. A final report, due to be delivered before the end of 2022, will capture additional detail and considerations from the, as well as the result of the coming months of deliberation.

GHG EMISSIONS SUBLIMITS FOR RESIDENTIAL AND COMMERCIAL & INDUSTRIAL HEATING AND COOLING

The 2025 GHG emissions sublimit for the Residential Heating and Cooling sector is 10.8 $MMTCO_2e$, or a 29% reduction from 1990 level. The 2030 GHG emissions sublimit for the Residential Heating and Cooling sector is 7.8 $MMTCO_2e$, or a 49% reduction from 1990 level.

The 2025 GHG emissions sublimit for the Commercial & Industrial Heating and Cooling sector is 9.3 $MMTCO_2e$, or a 35% reduction from 1990 level. The 2030 GHG emissions sublimit for Commercial & Industrial Heating and Cooling sector is 7.2 $MMTCO_2e$, or a 49% reduction from 1990 level. Below, Table 5.1 shows the historical emissions and the sublimits for 2025 and 2030.

Table 5.1. Emissions from Residential, Commercial, and Industrial Heating

Residential Heating and Cooling	1990	2010	2015	2020	2025	2030
Gross Emissions ($MMTCO_2e$)	15.3	13.7	13.6	12.2	**10.8**	**7.8**
% Reduction (Increase) from 1990		10%	11%	20%	29%	49%
Commercial & Industrial Heating and Cooling	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**
Gross Emissions ($MMTCO_2e$)	14.2	10.6	11.1	10.5	**9.3**	**7.2**
% Reduction (Increase) from 1990		26%	22%	26%	35%	49%

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

While the Commonwealth is required to set a single sublimit for the combined Commercial & Industrial sector, the two sectors are separated for the purposes of this document and in supporting analyses. This chapter discusses the main policies and plans for 2025 and 2030 to achieve emissions reductions from fossil fuel combustion in residential and commercial buildings. Space and water heating drives the majority of this energy demand, thus electrification and weatherization are the main policy focus.

In contrast, industrial energy consumption differs significantly from residential and commercial building energy demands. It tends to involve high-intensity processes related to manufacturing goods and products; relevant mitigation solutions focus on industrial hygiene and technical assistance, similar to policies implemented for the abatement of pollutants from non-combustion industrial processes (e.g., CO_2 emissions as a byproduct of lime manufacturing). Thus, policies to reduce industrial energy emissions reductions are discussed in Chapter 7, alongside policies to achieve the Commonwealth's Industrial Processes sublimits.

Table 5.2. Emissions from Residential and Commercial Buildings

Buildings (Res. & Com.) Sector Emissions	1990	2010	2015	2020	2025	2030
Residential	15.3	13.7	13.6	12.2	10.8	7.8
Commercial (without Industrial)	8.4	6.7	7.6	7.3	6.4	4.7
Total Gross Emissions ($MMTCO_2e$)	**23.8**	**20.4**	**21.2**	**19.5**	**17.2**	**12.5**
Total Percent Reduction from 1990		**14%**	**11%**	**18%**	**28%**	**47%**

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

STRATEGY B1: CAP ON EMISSIONS FROM HEATING

The 2021 Climate Law requires **sector sublimits** for 2025 and 2030, which represent a legally binding and declining cap on GHG emissions from heating fuels. The statute also charges the MassDEP with promulgating "regulations regarding sources or categories of sources that emit GHG to achieve the GHG emissions limits and sublimits." As a part of the Commission on Clean Heat's preliminary recommendation, before the end of 2022, MassDEP will initiate a stakeholder process on technical aspects of program design, with a goal of finalizing regulations by the end of 2023 so that the requirements can take effect as early as 2024. In developing the regulations, MassDEP will consider lessons learned from other jurisdictions and from implementing caps and standards in other sectors, and include mechanisms to allow flexibility, limit costs, and ensure equitable outcomes.

Under this proposed strategy from the Commission on Clean Heat, MassDEP will develop a high-level program to meet the emissions limit for residential, commercial, and industrial heating. MassDEP will develop a set of draft regulations that addresses questions relating to the (a) specific entities regulated, (b) the reporting process, (c) the role and magnitude of alternative compliance payments, (d) the use of any revenues associated with the program, and (e) other design features. One of the regulatory options being considered by the Commission on Clean Heat is to develop a **Clean Heat Standard** for buildings. As a preliminary consideration, a Clean Heat Standard could require heating energy suppliers, including suppliers of delivered fuels, natural gas, and/or electricity, to earn or purchase credits representing an increasing percentage of buildings that have reduced emissions due to retrofits that decrease the energy footprint and utilize clean heat technologies, such as electric heat pumps. As a part of the analysis to develop this 2025/2030 CECP, and ahead of MassDEP's regulatory process, the Commission on Clean Heat, supported by research from the Interagency Clean Heat Task Force and the Regulatory Assistance Project, has developed preliminary descriptions of the potential components of a Clean Heat Standard, which can in turn be considered by future regulatory deliberations. This preliminary description of the potential features of a Clean Heat Standard is included as Appendix B.

STRATEGY B2: PERFORMANCE BENCHMARKS & STANDARDS

Building standards for new construction represent a critical component of the strategy to promote building electrification. Building stock turns over slowly, and almost all buildings constructed in the 2020s are expected to still be operational in 2050. To limit new emissions and emission sources in the

Buildings sector, it is a top priority to encourage the design of new buildings and building energy systems to be 2050-compliant, avoiding any need for future retrofitting. This step is necessary to achieve 50% emissions reduction economy-wide in 2030 and maximize the Commonwealth's ability to achieve net zero in 2050.

As discussed in the Interim Clean Energy & Climate Plan for 2030 and directed by the 2021 Climate Law, DOER is promulgating a high-efficiency **specialized opt-in energy code** for which municipalities can choose to adopt starting in December 2022. The specialized code reflects more stringent energy standards that align with the Commonwealth's long-term building decarbonization goals. In addition, DOER is updating the **stretch energy code** which most municipalities have currently adopted as a prerequisite to enrolling in the **Green Communities Grant Program**. Together these updates will significantly reduce emissions from new construction over the coming decade.

Highly efficient building envelopes with wide-spread adoption of electric heat pumps or other clean heating solutions can be deployed for little to no incremental cost when constructing a new building. However, for existing buildings, incentives will be necessary to advance the deployment of deep retrofits that include weatherization (increased insulation to building envelopes) and transition of the fossil fuel-based heating systems to electric heat pumps or other clean resources. Several different emissions standards could incentivize developers to meet a declining emissions cap for heating. The Commonwealth's existing **Alternative Energy Portfolio Standard (APS)** provides a market incentive for businesses, institutions, and governments to install and operate a range of eligible alternative energy systems, including renewable thermal technologies. Much like the Renewable Portfolio Standard, the APS represents a credit obligation on the Commonwealth's retail electric utilities, meaning that these incentives are financed through electricity bills. In 2022, DOER will begin administrative processes to revise the APS program to align with the Commonwealth's 2025 and 2030 limits and sublimits. Currently, the proposed changes to the program include increasing the APS Alternative Compliance Payment (ACP) to align with the RPS Class I ACP at $40, beginning in 2023.[27] This change would increase the value of renewable thermal energy to be equal to renewable electric energy. Additionally, the APS will prioritize technologies which provide the most impactful GHG emissions reductions. The proposal includes phasing out natural gas combined heat and power systems (CHP) by 2030 while continuing to support renewable thermal and fuel cell technologies. The long-term future of APS, including its interaction with electricity rates, will be part of the continued deliberations and final recommendations from the Commission on Clean Heat.

Another building standard under consideration by the Commission on Clean Heat would require the roll out of building energy reporting programs and emissions intensity benchmarks. This plan does not create an emissions standard that requires each building to meet an emissions limit or emissions intensity limit. Instead, to prepare for a future where the emissions from each building can be tracked, the Commission on Clean Heat is considering **a uniform and consistent energy performance reporting approach** for a range of building types that could be available for cities and towns to use on an opt-in basis**.** One of the key challenges to building retrofits and energy efficiency upgrades is the split interests between building owners and renters in leased buildings, especially residential rental properties, where building owners must pay for building retrofits and system upgrades, but occupants benefit from those

[27] https://www.mass.gov/doc/aps-straw-proposal/download.

improvements through increased comfort and reduced energy bills. Building energy reporting can support market transparency and informed decision-making by homeowners, renters, and landlords about their building's energy costs and emissions footprint. For larger, mostly commercial, buildings, encouraging annual reporting can present a key lever to improve building energy performance. Cambridge has begun to track building energy data, while both Boston and New York City have implemented **building energy reporting ordinances** for properties over a certain square footage threshold and require that those buildings meet declining energy intensity (energy used per square foot) benchmarks over the coming decades.

BOSTON'S BUILDING EMISSIONS REDUCTION AND DISCLOSURE ORDINANCE (BERDO)

In Boston, buildings account for 70% of citywide GHG emissions and just 4% of buildings account for more than half of those emissions. The original BERDO, adopted in 2013, required that buildings 35,000 square feet and over report their annual energy use and carry out an energy action or assessment every five years. After this important first step, starting in 2020, the City of Boston began a collaborative process to update the ordinance with carbon targets, set by building type, that ramp down to net zero by 2050. The new policy seeks to give buildings the flexibility to choose how they fit those targets into their capital improvement cycle.

Boston worked to center environmental justice in its policy development and seven other jurisdictions across the country have adopted similar policies. A Technical Advisory Group informed the development of emissions targets, using five years of benchmarking data reported under BERDO. The City also worked with community-based organizations to convene a Resident Advisory Group composed of residents living in potentially covered buildings in EJ communities, to ensure the policy centers their priorities and works to minimize harm and maximize benefits for frontline communities. Boston adopted and signed into law the resulting "BERDO 2.0" in 2021.

BERDO 2.0 expands coverage to buildings 20,000 square feet and up, or with at least 15 residential units. Recognizing that every building is different, it also creates pathways for owners to comply by combining their buildings into a larger portfolio, by applying for an individual compliance schedule, or by applying for a hardship compliance plan. A newly created Review Board, with two-thirds of members to be nominated by community-based organizations, would approve those pathways, as well as allocate funds from alternative compliance payments towards local building carbon reduction projects that prioritize emissions reductions in environmental justice communities.

Across Massachusetts, buildings with greater than 20,000 square feet add up to about 150 billion square feet and are about 30% of total built space in the Commonwealth, even if they only represent less than 5% of total structures. Boston's experience with BERDO and BERDO 2.0 will present important lessons learned for the rest of Massachusetts.

The Commission on Clean Heat also is considering approaches to roll out a framework for cities and towns to consistently calculate and report the energy use and GHG emissions of the building stock in their jurisdictions. If recommended by the Commission, DOER will develop the uniform building performance reporting approach and related technical resources by the end of 2023, with stakeholder input and in a manner that does not overly burden building owners. DOER conducted a pilot program for home energy scorecards in eight municipalities around Springfield in 2013–2014, in conjunction with routine Mass Save audits. The pilot program measured a 25% increase in the number of homeowners

that implemented efficiency projects after having a Mass Save audit compared to business-as-usual. Outside of energy audits, much of the information needed for a home energy scorecard is routinely collected by fuel suppliers and utilities. Realtors typically request additional information from building owners, such as boiler type, make, and vintage, when posting a property for sale or lease. Some entrepreneurs have begun to gather and compile such information and emerging data and technology firms may be able to provide home energy scorecards with minimal burden on building owners.

STRATEGY B3: DELIVERING RESULTS AT SCALE

Climate Finance and Centralized Technical Assistance

One central obstacle to widespread deployment of heat pumps is the high upfront cost of heat pump installations and weatherization retrofits, although these projects typically save money in the long term. As a part of the Commission on Clean Heat's deliberation and preliminary recommendation, **climate finance** programs can help address a portion of the cost barrier and expedite the deployment of clean heat solutions. A **climate financing mechanism** could be used to amplify the impact of investments by **attracting and leveraging private capital;** related financial products could help de-risk some of the building retrofit investments to help investors grow their interest in the projects. MassCEC is collaborating with the City of Boston to evaluate program models from green banks around the country. For example, the D.C. Green Bank has a Navigator Pre-Development Energy Loan which provides a line of credit to help fund the construction design for energy efficient upgrades to new and existing commercial, nonprofit-owned, and multifamily properties. That program is offered in partnership with Inclusive Prosperity Capital, a not-for-profit investment fund that channels investment capital to communities that need it most. Building on this research, the Commission on Clean Heat will continue to deliberate on and make final recommendations for how Massachusetts could set up a climate finance approach that encourages private sector investors to partner with public sector entities to invest in building retrofit projects.

In addition to pursuing a new climate financing approach to leverage capital investments into building decarbonization, the Commission on Clean Heat has discussed and suggested that the Commonwealth explore setting up a **centralized clean heat clearinghouse** to access consistent guidance, technical assistance, and grant financing to drive enrollment of "clean square feet." These resources could be made available to existing state and municipal programs and entities, starting with the **Municipal Vulnerability Preparedness**, **Green Communities**, and **Leading By Example** programs. In addition to the state and municipal buildings covered under those programs, access to the resources housed in the clearinghouse can be expanded to other agencies' programs, such as the **Mass Housing Partnership** and the **Mass Cultural Council,** in order to accelerate the deployment of clean energy and heating solutions, especially for the Commonwealth's public housing developments. The concept includes providing building projects that receive state-backed funding access to clean heat resources from the clearinghouse and aligning interventions with the Commonwealth's long-term decarbonization goals.

Mass Save®

For more than ten years, Mass Save has yielded immense consumer benefits and ranked among the top state-sponsored energy efficiency programs in the nation. A keystone of the Commonwealth's energy policy portfolio, Mass Save has begun the process of aligning with the state's GHG emissions reduction

targets and requirements. The **2022–2024 Mass Save Energy Efficiency Plans** were designed to accelerate investments in building envelope retrofits, electric heating, and wind down rebates for fossil fuel heating systems. These actions contribute to the changes in building components and equipment needed to meet emissions limits and sublimits set by this 2025/2030 CECP. As determined by the Secretary of EEA on July 15, 2021,[28] the implementation of these measures must generate cumulative emissions reductions exceeding 845,000 $MTCO_2e$, as measured in 2030. Mass Save is currently the best-resourced and farthest-reaching policy tool that the Commonwealth can leverage to achieve GHG emissions reductions from the Buildings sector. However, the gross emissions sublimits for the Residential and Commercial & Industrial sectors sum to 20.1 $MMTCO_2e$ in 2025 and 15.0 $MMTCO_2e$ in 2030. This indicates a reduction of approximately 5.1 $MMTCO_2e$ (before accounting for reductions from electricity emissions), between 2025 and 2030, nearly all of which the 2025-2027 and 2028-2030 Mass Save plans would need to shoulder. This chapter proposes several other key programs, especially those discussed in Strategy B1, which are still under deliberation by the Commission on Clean Heat, and which could account for much of this reduction instead of the Mass Save programs. In addition, as is being considered and recommended on a preliminary basis by the Commission on Clean Heat, and discussed below, the scope and nature of Mass Save may need to be updated to fully meet the emissions sublimit for 2030. Therefore, a more specific quantitative estimate of future plans' emissions reductions will depend on the conclusion of those deliberations and any proposed updates to the program.

The Commission on Clean heat will continue to deliberate if **legislation may be needed to update the role and charge of Mass Save**. As we move toward building and vehicle electrification, Mass Save should consider new funding mechanisms to maximize the climate benefits of its measures. Historically, most Mass Save investments have been recovered from electricity bills. This has had the effect of increasing the price of electricity relative to other energy sources, making electric heat pumps a less competitive option compared to traditional fossil fuel furnaces and boilers. In parallel with other policies that may impact energy costs and energy rates, how energy efficiency investments are financially backed requires further reevaluation to ensure that such investments drive decarbonization, not inhibit it. Going beyond funding mechanisms, the Commission on Clean Heat will evaluate the potential for a new model focused on reducing emissions, rather than only reducing energy use. Such a program could serve as a "one-stop shop" for the Commonwealth's residents, businesses, and others seeking to decarbonize their buildings, including those served by municipal utilities.

Reaching All Building Types and All Communities

The largest and most energy-intensive buildings in the Commonwealth represent another key opportunity to deliver building decarbonization at scale. Since the least expensive time to make a larger property low-emitting and high-performing is at the time of construction, **Massachusetts Environmental Policy Act (MEPA)** reviews include the environmental impacts of any large construction projects and develop approaches to mitigate environmental damage. These approaches include but are not limited to enhanced building designs that can reduce GHG emissions from energy consumption.

For existing large buildings, clean energy retrofits often require expensive upgrades which may have very long payback periods. MassDevelopment, in coordination with DOER, has begun to offer financing

[28] https://www.mass.gov/doc/greenhouse-gas-emissions-reduction-goal-for-mass-save/download.

options for businesses and developers through its **Property-Assessed Clean Energy (PACE)** program, which allows building owners to finance clean energy upgrades through a long-amortization, low-interest lien placed on the property itself. When the building is sold, the lien is transferred to the new owners—along with the benefits (such as lower energy bills) that the project provides. For both new construction and building retrofits, offering technical assistance, and expanding financing opportunities can help guide developers and building operators to evaluate clean energy options that work for a greater range of building types and uses and implement those solutions with minimal financial risk and maximal energy and environmental benefits.

In addition to commercial and public-sector buildings, arts and cultural centers and religious institutions represent the beating hearts of many communities. Since 2021, MassCEC's **EmPower** initiative has supported community-based organizations and non-profits looking to explore programs or projects that provide access to the benefits of clean energy for previously underserved populations. Prioritizing the retrofit of community centers and cultural hubs can provide access to the benefits of modern, efficient, and clean heating and cooling systems to entire neighborhoods, especially for EJ populations. This type of community-based investment can catalyze neighborhood-scaled retrofit programs—such as the EnergieSprong model developed in the Netherlands and recently deployed for affordable housing developments in New York—which can dramatically enhance the pace and quality of energy retrofits while reducing costs for participants. More than just bringing clean heating and cooling to communities across the Commonwealth, this type of local decarbonization planning can ensure participation of every community in the clean energy future.

Picture 11. MassCEC's Billboard as Part of the Clean Energy Lives Here Campaign

As the building sector prepares for a major pivot to achieve the 2025 and 2030 GHG emissions limit and keep the Massachusetts economy moving toward net zero by 2050, it will be critical to nurture the market by testing new approaches and broadening the awareness and understanding of clean heat solutions. MassCEC is the state economic development agency dedicated to accelerating the growth of the clean energy sector, and its current **Accelerator Grant** and **Decarbonization Pilot** programs seek to unlock innovative technologies that can reduce costs and demonstrate successful applications for all building types, as well as spur new business models for the market development of heat pumps and building envelope improvements. MassCEC continues to publish resources and market characterizations, engaging with commercial property owners and managers, architects, engineers, and the construction industry to identify opportunities to reduce the cost of building decarbonization solutions. Since 2020, MassCEC has run **Clean Energy Lives Here***,* a consumer education and engagement campaign around home decarbonization. This platform supports consumers in their building decarbonization journey, from

initial education to planning and implementation. MassCEC will continue to expand these efforts and coordinate with new incentives and marketing efforts around building electrification from **Mass Save**.

In 2022, MassCEC is initiating a **Workforce Needs Assessment** based on the state's climate commitments. The study will include best practices for engaging and supporting women- and minority-owned businesses, EJ populations, and fossil fuel workers to transition to clean energy occupations. Devoting additional funding intended for economic development could expand the scope of these efforts to match the scale and challenge of building decarbonization.

PARTIAL-BUILDING HEAT PUMP USAGE

All air conditioners are heat pumps—some models can reverse the thermal flow to provide space heating in addition to space cooling. Approaching building electrification through space cooling deployment helps to resolve two key non-cost market barriers. First, air conditioners tend to have shorter lives than furnaces and boilers; this increases the number of potential replacement opportunities between now and 2030. Second, many space heating units are replaced upon failure, rather than simply when the unit's anticipated lifetime is exhausted. Since point of failure is typically during a time of heating demand, most homeowners will elect to install whatever is available most readily, rather than consider alternatives, even if the alternative is both economically and environmentally beneficial. In contrast, a heat pump has the same footprint as an air conditioning unit making installation quicker and easier than during an emergency replacement.

When installing a heat pump to provide air conditioning, homeowners can elect to install a unit sized for cooling needs or for heating needs. In Massachusetts, winters are colder than summers are hot, so a unit sized for cooling typically will only be able to meet 50-80% of a household's heating needs, with the remainder served by an existing heating system that is likely still fossil-fuel based. This is what some call a **"hybrid" heat pump system**. While partial electrification through the use of such hybrid systems can provide significant GHG reductions by 2030, a hybrid strategy alone makes achieving net zero in 2050 more difficult and expensive for all customers. Reliance on a hybrid strategy requires continued maintenance of redundant heating and fuel distribution systems—both the utility infrastructure that all ratepayers finance as well as individual equipment purchases by homeowners.

Policies and recommendations in this Plan seek to balance this tension. Partial-building heating systems can provide near-term reductions and help consumer experience by using heat pumps immediately. However, we must simultaneously plan for future equipment and infrastructure investments needed to drive the widespread full-electrification of homes to achieve long-term decarbonization goals at least-cost to consumers.

PATHWAYS MODEL: NATURAL GAS PRICING (RATES) BY SCENARIO

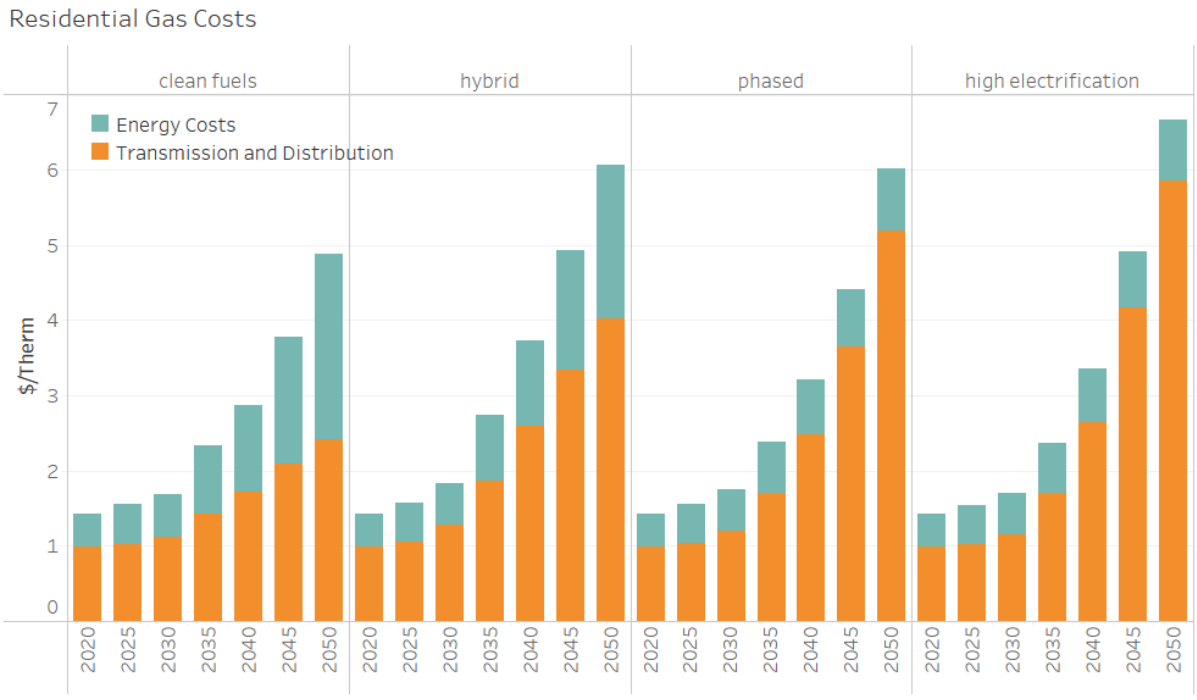
Both pipeline gas and electric bills include two key cost areas: the cost of the energy itself and the cost of the infrastructure that delivers that energy to a home or business. The annual cost of electricity infrastructure tends to be driven by peak electricity load—the maximum amount of electricity that the grid can deliver simultaneously. The annual cost of gas infrastructure is driven by the number of miles of pipeline that the utilities have installed and must maintain.

Although the cost of energy rises and falls with the cost of out-of-state energy purchases, the cost of annual maintenance and debt service from capital projects is relatively fixed. Across the decarbonization scenarios the Commonwealth modeled— including those evaluated by the utilities in Department of Public Utilities (DPU) Docket No. 20-80 and including scenarios heavily reliant on drop-in alternatives to electrification—total pipeline gas consumption (including what is used for electricity generation) declines significantly through 2050 to meet decarbonization targets. Since fixed infrastructure costs will continue to accrue regardless of gas throughput, a similar total cost will be spread over a decreasing amount of energy sales, resulting in rising prices per unit of natural gas delivered. Furthermore, gas infrastructure investments are traditionally recovered through customer rates over a long period of time to reflect the long lifetime of the assets themselves—meaning that utility investments made today will still need to be paid for many years in the future.

Figure 1.1 below shows the average delivered cost of pipeline gas to residential customers through 2050 under four Pathways: Clean Fuels, Hybrid, Phased, and High Electrification. Importantly, none of these scenarios presents a sustainable future for delivered pipeline gas costs to consumers under existing utility ratemaking approach. Customers experiencing such high delivered price of gas would likely convert to available alternatives, presenting a key equity challenge for customers without capital resources to make such a switch who will be stuck with increasing energy bills.

Delivered gas costs would increase dramatically because the fixed costs, including investment costs of the gas pipeline system, will need to be spread across a decreasing amount of gas throughput for the Phase and High Electrification scenarios. As for the Clean Fuels and Hybrid scenarios, the number of customers connected to the gas system is assumed to be the same as in the Reference case, and the pipeline throughput declines are less severe than the other two scenarios (driven by increasing end-use efficiency, modest electrification, and reductions in gas electricity generation). However, as more high-cost renewable and synthetic natural gas is needed to meet demand, the delivered cost of those fuels for the remaining customers would increase significantly relative to today's conventional natural costs. These cost impacts are shown for residential customers, but the same trends impact commercial and industrial gas customers—though residential customers are more heavily impacted by increasing delivery costs, while commercial and industrial customers' bills are more sensitive to energy cost increases.

Figure 5.1. Average Delivered Cost of Pipeline Gas to Residential Customers through 2050 under Four Pathways: Clean Fuels, Hybrid, Phased, and High Electrification



STRATEGY B4: INFRASTRUCTURE PLANNING AND TECHNOLOGY INNOVATION

Transitioning our buildings from oil and natural gas to electricity will have profound impacts on our electric grid and our natural gas distribution infrastructure. Responsible **energy infrastructure planning** is thus a key priority for building decarbonization. For the electricity grid, deployment of electric heat pumps will significantly increase both total annual demand for electricity and the demand required during the coldest hours of the year. Although it is unlikely that heat pump adoption would drive peak growth until sometime after 2030, investment in electric infrastructure should be planned today. Since such investment increase comes with increasing aggregate demand, especially considering the impacts of transportation electrification, the 2025/2030 CECP analysis suggests that electricity prices will remain relatively stable. However, it is possible that the estimated electricity distribution and transmission system upgrade costs are underestimated. Meanwhile, as the number of natural gas consumers begins to decrease, the state will face critical questions about the future of its natural gas distribution infrastructure (see Pathways Model call-out above).

Considering the potential implications that deep decarbonization holds for the future of gas infrastructure and gas customers, the Massachusetts DPU issued an order in October 2020 opening **Docket 20-80**, an investigation into the role of the investor-owned gas utilities in a net zero economy in 2050. Natural gas utilities were asked to present potential regulatory reforms that might be needed to support the reduction of GHG emissions from natural gas usage in the Commonwealth. To date, the proceedings and filings from the gas utilities have focused on modeling possible futures, identifying alternatives to the pathways modeled in the 2050 Roadmap Study, and developing high-level plans to

meet the decarbonization goals. As a next step toward establishing a robust Future of Gas plan, the Commonwealth and the utilities should develop and implement solutions to protect ratepayers from the likely price increases associated with decreasing gas throughput over time.

The effort to decarbonize building heat systems and transition away from fossil fuel based heat systems should include coordinated planning with the electric utilities to facilitate electrification alongside the targeted decommissioning of the natural gas pipeline systems. This approach needs to ensure reliability of both the natural gas and electricity systems while advancing the transition, and protecting all ratepayers from significant cost burdens, particularly those who are most vulnerable to those increases. A review of the gas system enhancement plan may be useful in identifying areas where additional investment may have greater costs than benefits; see Chapter 7 for more details.

As a part of the transition toward a clean energy future, the electric utilities will need to evaluate the options for innovative rate structures to help promote EVs and heat pump adoption. The DPU will work with the electric utilities and stakeholders to develop alternative **rate structures** for customers with electric heating (similar work on electric vehicle charging is ongoing) that would increase incentives for the adoption of clean technologies, while protecting energy-burdened households to ensure that everyone across the Commonwealth can reach equal and fair access to the clean technologies.

CHAPTER 6: TRANSFORMING OUR ENERGY SUPPLY

6.1 SECTOR OVERVIEW

The Commonwealth has made significant progress in decarbonizing its electricity generation and energy supply systems. Since 1990, power sector emissions have decreased by nearly 50%, in large part due to the closure of coal- and oil-fired power plants. Preliminary estimates indicate that, in 2020, the electricity sector in Massachusetts accounted for 12.8 MMTCO2e, or approximately 20% of statewide emissions. Natural gas power plants in Massachusetts emitted 44% of that total, while emissions associated with electricity imports from fossil fuel generators elsewhere in New England contributed 46%; municipal waste combustors contributed the remaining 9%. Renewable and clean generation resources, including wind, solar, nuclear energy and hydroelectric meet about half of the New England grid's total electricity demand.[29] Despite progress in reducing electricity sector emissions, significant work is still needed for Massachusetts to meet its anticipated electricity demand with clean and renewable resources, which is essential for achieving economy-wide decarbonization by mid-century.

Electricity demand has declined moderately in the past decade, due in part to energy efficiency investments, such as those sponsored by Mass Save, which are discussed in Chapter 5. However, electricity demand is projected to increase significantly by 2050 due to the widespread electrification of building and transportation services. Thus, the emissions intensity of electricity generation must continue to decrease even while total generation increases. The Commonwealth anticipates offshore wind will be the primary source of electricity for its decarbonized energy system, all of which would need to be interconnected to land in Massachusetts or other parts of the New England grid. Solar resources represent a key complementary resource, reaching peak production during the day and summer compared to offshore wind's peak production at night and in the winter.[30] However, reliably operating a cost-effective, ultra-low emissions electricity grid based on variable renewable resources requires a balanced portfolio. The addition of large amounts of intermittent sources of power such as wind and solar will require deployment of complementary technologies, such as firm clean energy imports, and resources that can help balance periods of low wind and solar production, as well as reduce energy costs throughout the region. In addition, electricity storage and smaller distributed energy resources can help maintain grid reliability. The 2050 Roadmap Study, updated and refined to achieve the 2025 and 2030 limits, shows that the transmission and distribution systems will need significant upgrades to support a decarbonized economy.

Since the 1970s, the Commonwealth's bulk electricity system has been operated in close coordination with other New England states, first as part of the New England Power Pool (NEPOOL) and then within the operational jurisdiction of the regional ISO-New England.[31] Massachusetts continues to work with other New England states and ISO-New England to reform and improve the regional wholesale electricity market and system planning processes, as the energy system needs to transition to

[29] https://www.iso-ne.com/about/key-stats/resource-mix/.
[30] The 2050 Roadmap and Energy Pathways Report provides additional details.
[31] ISO-NE is the FERC-regulated independent system operator for New England.

accommodate, and incorporate the clean energy resources needed by the New England states to decarbonize their economies.

6.2 ACHIEVING 53% IN 2025 AND 70% IN 2030 FOR ELECTRICITY SECTOR

To achieve a statewide 50% GHG emissions reduction economy-wide below the 1990 baseline in 2030, GHG emissions from the electricity sector must decrease by more than 53% by 2025 and 70% by 2030, as shown in Table 6.1. The Commonwealth expects emissions from the electricity system in 2030 to come from a combination of in-state fossil fuel generation, municipal solid waste combustion, and imported fossil fuel generation. Both the RGGI, the regional cap-and-trade program for power generators in eleven Northeastern states, and the Commonwealth's regulations on in-state power generators and the electric distribution companies (EDCs) provide a long-term framework for continuing to reduce GHG emissions from the electricity sector. Achieving these emissions goals, while accommodating new load growth due to building and transportation electrification and ensuring an affordable and reliable grid requires careful planning and a range of policy tools.

Renewable energy sources already comprise a growing portion of power generation within the Commonwealth and across New England. The six states in the region all have portfolio standards, which require that the region's many electric utilities sell a certain blend of clean power to their customers and provide some guidance for resource eligibility. Together with other regulatory requirements, Massachusetts and other New England states have been advancing the deployment of clean energy resources. Since state-specific policies operate in the shared New England grid, coordination across all six New England states is essential to continuing the momentum of these efforts and accelerating regional resource development between now and 2050. Such coordination and collaboration include the ongoing effort to invest in a flexible, responsive, and reliable electricity grid; developing and using a wholesale electricity market that supports state policy objectives; planning for increased transmission capacity and changes to cost allocation for infrastructure development among the states; and developing partnerships across state and international borders to ensure the entire Northeast region moves cost-effectively toward a shared clean energy future .

GHG EMISSIONS SUBLIMITS FOR ELECTRIC POWER

The 2025 GHG emissions sublimit for the electric power sector is 13.2 $MMTCO_2e$, or a 53% reduction from 1990 level. The 2030 GHG emissions sublimit for the electric power sector is 8.4 $MMTCO_2e$, or a 70% reduction from 1990 level. Table 6.1 illustrates the gross GHG emissions attributable to the electricity sector in 1990, 2010, 2015, and 2020, compared to the electricity sector sublimits for 2025 and 2030.

Table 6.1. Emissions from Electric Power Sector

Electric Power	1990	2010	2015	2020	2025	2030
Gross Emissions ($MMTCO_2e$)	28.0	22.9	15.6	12.9	**13.2**	**8.4**
% Reduction (Increase) from 1990		18%	44%	54%	53%	70%

Note: GHG emissions for 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

STRATEGY E1: EXECUTE CLEAN ENERGY PROCUREMENTS

The current clean energy procurements planned to be in service by 2030 set Massachusetts on a path toward deep decarbonization. In 2016, the Commonwealth first established ambitious targets for electricity procurement from clean energy and offshore wind. The original legislation, An Act Relative to Energy Diversity, required utilities to solicit a total of 1,600 MW of offshore wind by 2027, which is currently under contract with the Vineyard Wind and Mayflower Wind offshore wind projects. The offshore wind procurement target was increased in 2018 and again in 2021 to a total of 5,600 MW. The most recent procurement of 1,600 MW of offshore wind was conducted in 2021, with the selection of a portfolio of projects from Commonwealth Wind (1,200 MW) and Mayflower Wind (400 MW).

Picture 12. Vineyard Wind Groundbreaking

In addition, New York, Rhode Island, and Connecticut have procured a combined 3,740 MW of offshore wind capacity from the lease areas south of Massachusetts, with more procurement authority remaining. Offshore wind is a rich and abundant resource that Massachusetts can deploy as a driver of both economic development and emissions reductions for the New England electricity grid. Offshore wind must be properly sited to minimize negative environmental impacts on marine and coastal ecosystems and to promote co-existence with existing marine uses like commercial fishing. In coordination with other states and federal partners and stakeholders, planning for future lease areas and a transmission system to support increased offshore generation will also be necessary to guide the region's growing industry to meet local clean energy needs. Please see Strategy E4 for more details on these efforts.

REGIONAL CLEAN ENERGY AND TRANSMISSION INFRASTRUCTURE

The Commonwealth's energy pathways analysis simulates electricity demand and supply from all six New England states as well as neighboring regions of New York, Québec, and New Brunswick. In almost every deep decarbonization scenario, new transmission capacity to import firm hydroelectricity from Canada is found to be a significant least-cost clean energy resource for the region largely because it complements and balances offshore wind generation, reducing energy costs for the entire region. In a modeling scenario in which new transmission to Québec was constrained, new transmission to neighboring states to access other clean energy resources emerged as the next most affordable option.

In the 2050 Roadmap Study, an analysis that constrained the availability of dispatchable natural gas generators that would otherwise fill in during times of low renewable production suggested that more ground-mounted solar PV paired with storage is the next-lowest cost solution to replacing dispatchable resources such as hydroelectric energy. Replacing the 9.5 TWh per year of clean energy contracted for under NECEC would require an equivalent of about 8 GW of additional ground-mount solar. At an average of approximately 4 acres of land per MW of solar, such a large amount of solar PV investment would require more than 30,000 acres of land.

In addition to local projects, developing and sharing clean energy resources across a more diverse set of technologies and broader geographic area has been demonstrated to reduce costs and increase grid reliability. In 2018, the Commonwealth's electric utilities completed a competitive solicitation for 9.5 terawatt hours (TWh) per year of clean energy generation, to deliver Canadian hydroelectric generation through the New England Clean Energy Connect (NECEC) transmission project. NECEC was fully licensed and permitted and had begun construction, until progress was stalled due to a statewide referendum in Maine. The NECEC project owners are currently challenging the referendum. Nonetheless, the project represents a key opportunity to bring cost-effective and reliable clean energy to the New England electricity system. While the NECEC project is a critical component of Massachusetts' ability to achieve its emissions limits, Massachusetts will need additional transmission capacity to deliver additional renewable electricity into the market as we approach net zero in 2050.

Today, alternatives to new firmly delivered hydroelectric resources and in a deep-decarbonized future are limited to resources like gas and oil combustion plants or ground-mounted solar paired with utility-scale battery storage technologies. Analysis of the power system suggests that additional clean energy resources are likely to be needed to ensure there are sufficient balancing resources available when intermittent renewable energy is not available. Additional procurements for clean energy resources, including hydroelectric, offshore wind, onshore wind, and other clean energy resources, will help Massachusetts meet its net zero goals in 2050.

STRATEGY E2: CLEAN ENERGY ATTRIBUTE MARKETS

The Renewable Energy Portfolio Standard (RPS), which includes Class I and Class II eligibilities, the Alternative Energy Portfolio Standard (APS), and the Clean Energy Standard (CES) require the Commonwealth's electricity suppliers to sell an increasing share of electricity from clean resources. The 2021 Climate Law raised the RPS minimum standard to 40% by 2030. Subsequently, MassDEP has proposed to increase the CES minimum standard to 60% by 2030 (20% incremental above the RPS).[32] The CES supports additional clean energy that does not qualify for RPS, including nuclear and large hydroelectric generation. Thus, any new resources, including additional clean energy that can be imported to the New England grid would qualify. In addition, the CES for existing resources (CES-E) provides support for existing nuclear and large hydroelectric resources in New England. As currently promulgated, the CES-E would apply to about 20% of retail load in 2030 over and above the proposed 60% for CES.

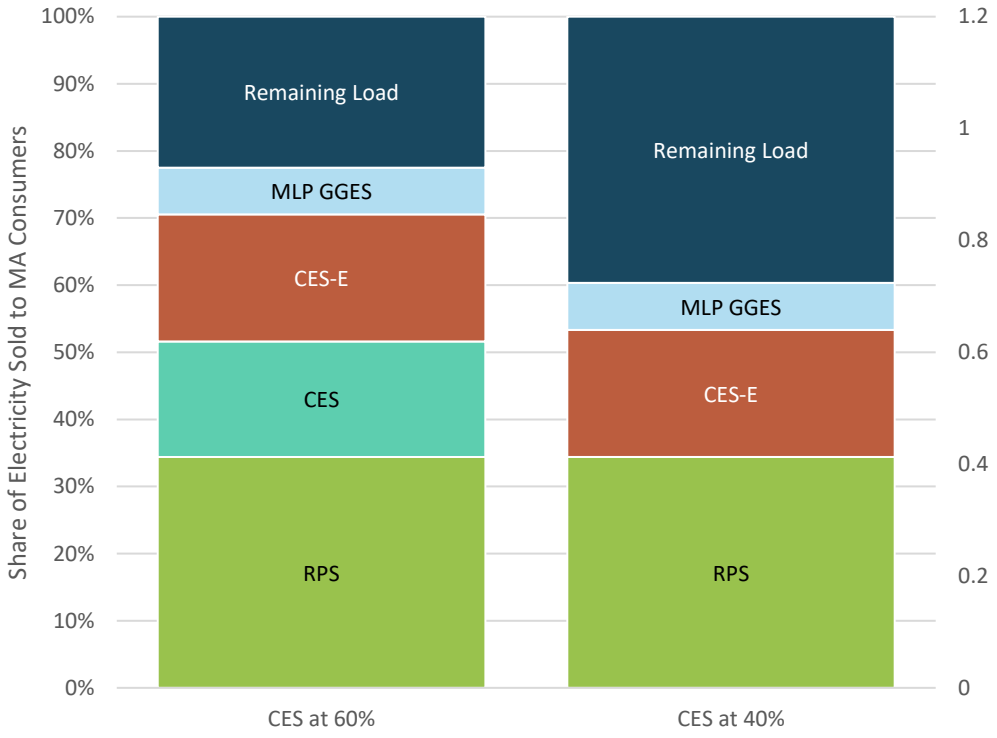
The Commonwealth's 41 municipally-owned utilities called municipal light plants (MLPs) are exempt from the RPS, APS, and CES, but the 2021 Climate Law created an MLP Greenhouse Gas Emissions Standard (GGES). This new standard requires the MLPs to supply their customers—about 14% of statewide load—with a 50% clean energy in 2030. As a part of the 2025/2030 CECP, the MLPs are expected to meet the 50% of clean energy supply, which will be *incremental* to the clean energy resources used to serve the customers of the investor-owned EDCs. Overall, as shown in Figure 6.1

[32] MassDEP has proposed amendments to 310 CMR 7.75, April 2022. Can be found at https://www.mass.gov/doc/310-cmr-775-proposed-clean-energy-standard-amendments/download.

below, the various standards (RPS Class I, RPS Class II, APS, CES, CES-E, and MLP GGES) will require clean energy supply to serve more than 75% of Massachusetts' electric load.

The Commonwealth has additional regulations and programs that aim to reduce GHG emissions in the electricity sector. The Electric Generator Units (EGU) emissions cap (310 CMR 7.74) sets a declining cap on carbon dioxide emissions from large power plants physically located in the Commonwealth. Emissions from power plants in Massachusetts are also subject to the emissions limits set by RGGI. This regional emissions trading program helps ensure that emissions reductions are realized across the region, not just in Massachusetts.

Figure 6.1. Electricity Supplier Obligations in 2030



STRATEGY E3: DEVELOP AND COORDINATE REGIONAL PLANNING AND MARKETS

As Massachusetts and its neighbors work toward a common clean energy future, cooperation, and coordination with other New England states and across the Northeast will help to ensure that renewable energy resources are utilized in the most effective manner and accomplish joint goals for deep decarbonization. In addition, because sharing resources across larger areas can reduce cost and is necessary to ensure the reliability of a deeply decarbonized electricity grid, **regional cooperation on electricity system planning and advancing wholesale electricity market reforms** will be necessary. Massachusetts will continue to lead in working with other states and the ISO-New England to advance the necessary changes in the way the New England electricity market and system function. Recognizing the urgency for, and complexity of, such change, Governor Baker, along with four other New England Governors, issued a joint statement in October 2020 articulating the need for comprehensive,

decarbonization-focused reform of the regional electricity system.[33] Referencing the 2050 Roadmap analysis and similar modeling in other states, the Governors described the misalignment that is evident between today's grid and the one needed to achieve the states' deep decarbonization goals. Going forward, that misalignment must be corrected so that the Commonwealth and other New England states working toward deep decarbonization are served by a regional electricity system operator and planner that is a committed partner in their decarbonization efforts. The required changes include:

- Develop market-based mechanisms, in concert with state policymakers, that facilitate growth in clean energy resources and enabling services, while fully accounting for ongoing renewable energy investments made pursuant to enacted state laws.
- Conduct best-in-class system planning activities that proactively address state clean energy needs.
- Ensure grid resiliency and reliability at least cost in a manner that is responsive to state and consumer needs.

Through the New England States Committee on Electricity (NESCOE), the New England states have issued a vison statement with detailed recommendations regarding how to begin immediate collaborative work to correct that misalignment.[34] Following an extensive stakeholder process and set of technical conferences, NESCOE issued a report on *Advancing the Vision* in June 2021 with updated recommendations on reforms related to market design, transmission planning, governance, and equity.[35] Massachusetts will continue to work with other New England states to explore new market designs to improve the way clean energy is valued in regional energy, capacity, and ancillary services markets. The states are also working with ISO-New England on changes to its transmission planning tariff to integrate a long-term transmission planning process that reflects state clean energy policies.

Reforms outlined in the NESCOE Vision are consistent with the direction the Federal Energy Regulatory Commission (FERC) is setting at the national level. In July 2021, FERC issued an Advanced Notice of Proposed Rulemaking (ANOPR) soliciting stakeholder input on a wide range of potential reforms to how transmission systems are built and paid for.[36] In April 2022, FERC followed with a Notice of Proposed Rulemaking to further advance the reforms necessary in transmission planning and cost recovery. Massachusetts will continue to be fully engaged with FERC to create opportunities for anticipatory, multi-value regional transmission planning processes that incorporate state public policies. These reforms will be important to ensure there is sufficient transmission to move energy from new clean resources to demand centers in a cost-effective manner.

[33] Governors Statement on Electricity System Reform 2020 (Oct. 14, 2020), http://nescoe.com/resource-center/govstmt-reforms-oct2020.
[34] New England States Vision Statement (Oct. 16, 2020), http://nescoe.com/resource-center/vision-stmt-oct2020.
[35] https://newenglandenergyvision.files.wordpress.com/2021/06/advancing-the-vision-report-to-governors-1.pdf
[36] https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20210715-3078&optimized=false

Solar and Other Distributed Energy Resources

As part of the State's RPS, the Solar Carve-Out (SCO) program, initiated in 2010 and extended through the SCO II program in 2014, requires electricity suppliers to meet a portion of the RPS obligation through solar energy. To further support the growth of solar and reduce ratepayer costs, Massachusetts launched the Solar Massachusetts Renewable Target (SMART) program in 2018 to incentivize the development of new solar generating capacity via a declining block tariff. In 2021, the SMART program received cost recovery approval to double its target to 3,200 MW, which will help propel further installation of new solar generation in Massachusetts.

Picture 13. Residential Solar PV

The Commonwealth's current solar incentive programs are anticipated to sunset after 2025, but the state and region will need to steadily continue to deploy solar generation over the next three decades to meet anticipated increased electricity demand in 2050. To support widespread electrification, New England likely will need more than 40 GW of solar resources by 2050. The supporting pathways analysis for the 2025/2030 CECP found this amount would exceed the total area of available rooftops in the region. To further assess the siting considerations for solar development, DOER initiated a Technical Potential of Solar Study in 2022. The study aims to complete a spatial analysis that will create a ranking of preferred and least preferred locations for solar in Massachusetts, considering environmental, land use, and economic factors. The study will recommend policies Massachusetts should consider to achieve its solar development ambitions. A thorough stakeholder engagement process will inform the direction of the study. The study will help to identify suitable sites for solar development and educate the public about the need to foster solar growth in Massachusetts while protecting our important natural and working lands.

Massachusetts is home to a vibrant economy of solar and storage development. However, the deployment of solar resources faces two significant challenges: interconnection of distributed energy resources and impacts on natural and working lands. Further policy will be needed to ensure sufficient solar deployment and to manage how such necessary development interacts with both of those systems. First, DOER, DPU, and MassCEC will continue to work with solar and storage developers and with the electric utilities and ISO-New England to remove or minimize any potential barriers in interconnecting new solar and storage resources. Interconnection of clean distributed energy resources (DERs) often requires upgrading the existing electric distribution and sometimes transmission systems to maintain power reliability standards. These efforts take time for adequate design, engineering, and planning. To integrate more solar and storage resources, both the distribution and the transmission systems will require anticipatory planning.

Second, coordinating the Commonwealth's need for additional solar resources with the need to protect valuable natural and working land, DOER will work closely with environmental protection agencies and stakeholders to ensure that the incentives provided to solar and storage projects do not unintentionally

harm valuable natural and working lands and forests. In addition, DOER will continue to encourage deploying solar and storage projects on "built" landscapes. These built environments include two million systems installed on rooftops and lawns, fields, roads, and parking lots, much of which may be suitable for deployment of solar and storage resources. The Technical Potential of Solar Study and resulting policy guidance will help indicate where and how much solar would be sited in the Commonwealth consistent with the protection of critical Massachusetts lands and habitat.

Third, Commonwealth has adopted the Energy Storage Initiative Target, which calls for 1,000 MWh of storage by 2025. While the Commonwealth is well on its way toward meeting the target, with over 300 MWh of energy storage installed as of the end of 2021 and over 800 MWh in the pipeline, the sector needs to be monitored as the technology continues to mature and markets are advanced. In particular, DOER will continue to assess the Clean Peak Energy Standard program and adjust the program as necessary to support the deployment of energy storage systems. The Commonwealth also will explore opportunities to support advancements of long duration storage, including advancing opportunities for clean hydrogen systems.

Offshore Wind

Offshore wind represents one of the most reliable clean energy resources available to Massachusetts and is critical to the development of a low-cost decarbonized electricity system for the Commonwealth and for New England. In 2021, the Biden-Harris Administration announced its ambitious goal to deploy 30 GW of offshore wind in the United States by 2030. The U.S. Bureau of Ocean and Energy Management's (BOEM) granted federal approval to the 800 MW Vineyard Wind offshore wind farm in 2021, paving the way for the **first-in-the-nation utility-scale offshore wind farm** to deliver clean power to Massachusetts. In addition, Massachusetts' EDCs have contracted another 804 MW from Mayflower Wind, a project that is under development. At the end of 2021, approximately another 1,600 MW of offshore wind projects were selected with proposed contracts under review. BOEM has committed to issue at least 16 federal siting approvals to offshore wind projects by 2025, which will propel the projects contracted to Massachusetts and neighboring states.

Picture 14. Lieutenant Governor Polito using Virtual Reality for Wind Turbine Testing

To support the growth of a healthy offshore industry, several important elements must move forward in parallel. First, Massachusetts must continue to work with neighboring states, federal agencies, and local municipalities to **design and deploy offshore and onshore transmission systems** to integrate the large amount of offshore wind projects in the waters of the East Coast. To do so, Massachusetts will work with neighboring states, federal agencies, and ISO-New England in developing a regional plan for offshore wind transmission. New programs authorized under IIJA may create new opportunities for the federal government to be a strong partner to support the development of a future-proof transmission system including new and innovative technologies and financing mechanisms.

Second, Massachusetts must **build a vibrant local economy around offshore wind that brings new jobs and significant economic investment** to the state. With strategic investments in key infrastructure—in the New Bedford Marine Commerce Terminal and the Wind Technology Testing Center in Charlestown—and in workforce development, supply chain expansion, and research and innovation, MassCEC already has helped establish the Commonwealth as a national hub and first mover for the offshore wind industry. To expand such efforts, Massachusetts will advance education and training programs to grow a new offshore wind workforce, expand local supply chains, support the redevelopment of and improvements to critical port infrastructure, and advance research and innovation. As a part of its commitment to increase the participation of underrepresented populations in the emerging offshore wind industry, MassCEC awarded $1.6 million in grant funding in July 2021 to eight organizations to reduce barriers to job entry and support the development of equitable, accessible offshore wind workforce training programs. Released in April 2022, the 2021 Massachusetts Clean Energy Industry Report shows that the clean energy sector has continued to grow. Encompassing more than 101,000 clean energy workers in Massachusetts, or 3% of the Commonwealth's workforce, the clean energy sector contributed over $13.7 billion to Massachusetts' Gross State Product in 2020.[37] In September 2021, MassCEC released a new report that identifies the strengths, gaps, and opportunities in the state for the offshore wind industry, which will guide its continued work in this area.

Third, Massachusetts needs to continue to work with other states and BOEM to **explore the expansion of offshore wind lease areas in federal waters**. In 2021, BOEM announced a schedule for leasing of new offshore wind energy areas in federal waters that includes a proposed lease sale for the Gulf of Maine in 2024. Massachusetts will continue to work closely with neighboring states, federal partners, and stakeholders as a member of the BOEM Gulf of Maine Intergovernmental Renewable Energy Task Force on the planning, analysis, and identification of new offshore wind lease areas. This collaboration will utilize existing geospatial information and continue to address known gaps, such as spatial data on the lobster fishery, to identify new lease areas that avoid and minimize potential adverse effects on commercial fishing and wildlife.

STRATEGY E5: INCORPORATE DECARBONIZATION GOALS INTO DISTRIBUTION SYSTEM MODERNIZATION

Distribution system planning and grid modernization will be required to maintain a reliable and resilient system as clean energy policies increase the number of DERs interconnected to the grid. A more dynamic, bi-directional distribution system will allow for greater electrification and optimize the integration of DERs. A modernized distribution system also will support the growth of EVs, distributed solar, energy storage and electric heating that provide lasting emissions reductions throughout the economy. As clean energy policies increase the use of the distribution system to support both the transportation and building sectors, a low-cost, reliable electricity system will become even more important for consumers.

With input from DOER and other stakeholders, the DPU is currently reviewing the utilities' proposed Grid Modernization Plans, which include implementation of Advanced Metering Infrastructure (AMI),[38]

[37] https://www.masscec.com/2021-massachusetts-clean-energy-industry-report
[38] D.P.U. Dockets 21-80, 21-81, and 21-82.

as well as the utilities' proposed Electric Vehicle Infrastructure Programs.[39] The deployment of AMI is a key technology to enable flexible electricity load including shifting electricity demand away from peak periods that are the most expensive and highest-emitting. This is especially important as electrification drives increased load from the heating and transportation sectors. Grid modernization includes using advanced data analytics to monitor and potentially control electricity usage. Such capabilities will enable end users to better manage their own electricity consumption to potentially help to reduce usage and reduce emissions from the power sector. For example, with data on instantaneous emissions rates of the power plants available to consumers, they can choose to reduce consumption during high-emitting periods. Such consumption changes based on emissions data are only possible with "smart grids" that could simultaneously help integrate distributed energy resources (such as solar and storage) and enable the electrification of buildings and transportation.

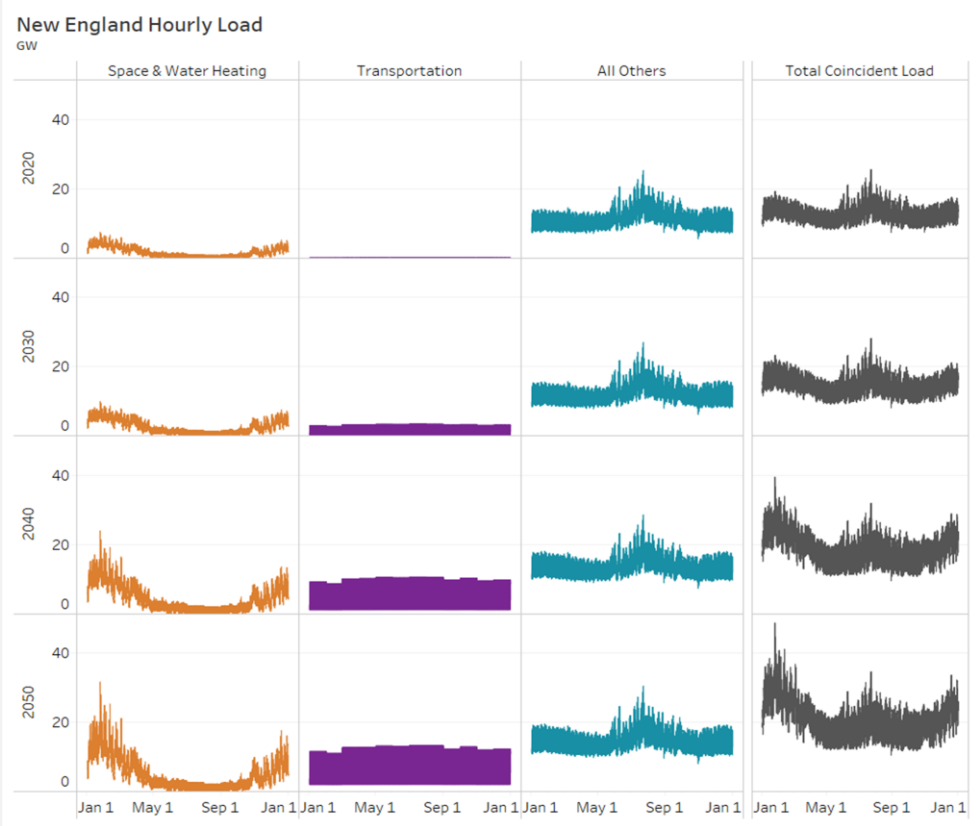
PATHWAYS ANALYSIS: ELECTRIFICATION AND ELECTRIC SYSTEM NEEDS

The decarbonization pathways analysis supporting these plans simulates the hourly electricity demand by aggregating loads from lighting, EVs, heat pumps, and other electronic appliances. The figure below shows the evolution of hourly annual electricity loads from 2020 to 2050 in New England. As the graph of the system load profile indicates in Figure 6.2, peak demand currently occurs during the summer in New England, driven primarily by space cooling. As electric heat pumps become more prevalent for space heating (and cooling), electricity demand in the winter is expected to grow, eventually shifting the system's peak from summer to winter. Such changes in electricity demand will require investment in the grid. The simulations show that electric space heating will not drive system peak until after 2030. However, since transmission development requires at least ten years of planning, design, siting, and deployment, it is important to incorporate the anticipated growth into today's transmission system planning.

If 10% of electric HVAC loads were allowed to be shifted by one hour, representing a very modest achievement of flexible load, Massachusetts could save ~$250 million per year in avoided electric capacity upgrades. As an example of how to achieve such flexibility, a 10 kWh Lithium-ion battery pack integrated into a 2-ton cold climate air-source heat pump could provide three hours of heating at peak heat pump draw (or significantly more under normal operating conditions), offering both peak mitigation and local resiliency in case of a power outage. In addition to the grid impacts of electrified space heating, in 2050, the adoption of about five million EVs is anticipated to add more than 20 TWh of electricity demand in Massachusetts. To date, most EV owners prefer to charge at home if possible; however, future charging behavior is uncertain. Heavy reliance on fast charging during the day could significantly strain the grid. On the other hand, five million EV batteries represent a significant fleet of distributed energy storage that could be used to offset peak demand and minimize system costs. As uses for electricity evolve and overall electricity demand grows through 2050, smart planning will be needed to leverage various sources of load flexibility to manage grid upgrade costs.

[39] D.P.U. Dockets 21-90, 21-91, and 21-92.

Figure 6.2. Pathways Analysis: Electrification and Electric System Needs



MassCEC, with support from the Electric Power Research Institute, is leading a stakeholder process with the EDCs to discuss how to consider future policy goals in distribution system planning and how to assess the distribution system upgrade cost associated with the transition to net zero in 2050. Incorporating decarbonization goals as a necessary parameter of planning processes would help identify opportunities for anticipatory planning, particularly since electrification of transportation and space heating are both dominant strategies for Massachusetts and both will require changes to the grid. Planning for the electrification of the Transportation and Buildings sectors requires considering long-term, cross-sector decarbonization goals that can help to implement sufficient electricity system upgrades. As utilities and utility regulators consider how and where to invest in transmission and distribution upgrades, an integrated, policy-aware planning and decision-making framework can reduce long-term ratepayer costs, while maintaining a safe and reliable grid and supporting decarbonization goals.

STRATEGY E6: DRIVING A JUST CLEAN ENERGY TRANSITION

To effectively integrate environmental justice and equity in the energy transition plan, the Commonwealth will need to undertake efforts including but not limited to: (a) ensuring that siting and permitting decisions consider the impact of energy projects on communities with EJ population, (b) incorporating the voices of those who have been traditionally underrepresented in policy and regulatory

processes and decisions, and (c) ensuring that well-paying jobs and economic development benefits flow to those who have traditionally not benefited from those investments.

While reforming programs, processes, and decision-making approaches is not always easy, Massachusetts is determined and committed to advancing a just clean energy transition, applying a "learning by doing" philosophy to quickly advance the incorporation of diversity and equity in every program and regulatory process. This will support the inclusion of diverse voices and enable informed decisions.

This effort is illustrated by DOER's most recent round of the offshore wind project solicitation. DOER incorporated environmental justice and equity as qualitative evaluation criteria in that procurement. As such, offshore wind bidders needed to describe any potential impacts, both positive and negative, on EJ populations and host communities, as well as to submit a Diversity, Equity, and Inclusion (DEI) Plan that described the bidder's strategy to promote access to employment and contracting opportunities for diverse workers, including people of color, women, veterans, people who identify as LGBT, and people with disabilities. When the contracts are complete, DOER will work with the selected developers, to track and report on progress toward EJ and DEI Plan goals. DOER will also work with the EDCs to ensure EJ and DEI criteria continue to be included in future offshore wind solicitations.

As another example, the DPU and the Energy Facilities Siting Board (EFSB) are developing EJ Strategies, which will include a Public Involvement and Community Engagement Plan (PIP). The EJ Strategies will be structured with a goal of equal protection and meaningful involvement by all people and communities with respect to the development, implementation, and enforcement of energy, climate change, and environmental laws, regulations, and policies. The EJ Strategies will also address the equitable distribution of energy and environmental benefits and burdens regardless of race, color, national origin, income, or English language proficiency.

To inform and refine these strategies, on April 16, 2021, and July 1, 2021, the DPU and EFSB, respectively, opened notice of inquiry (NOI) proceedings (D.P.U. 21-50 and EFSB 21-01) to examine procedural enhancements to respective public notice requirements and other practices to increase public awareness of and participation in the agencies' proceedings. Through the NOI process, the DPU and EFSB are exploring avenues to increase both the visibility of their public notices and public and stakeholder involvement in their respective proceedings. The DPU and EFSB are providing translated notices regarding proceedings that directly impact municipalities with EJ communities with limited English proficiency. In addition to evaluating input from relevant stakeholders, public officials, and members of the public on best practices for promoting public involvement in our proceedings, the DPU and EFSB will strive to ensure that EJ concerns are considered and the process for taking actions is consistent with EEA's Environmental Justice Policy.

The DPU and EFSB are also in the process of updating their respective Language Access Plans (LAP). The LAPs will detail the measures that DPU and EFSB staff must undertake to ensure that the public is afforded equitable access to the DPU's and EFSB's respective programs and services. The LAPs will be further refined based on public input received during the NOI process. The DPU expects to finalize and publish its LAP in tandem with the DPU EJ Strategy, including the PIP. Further, EFSB expects to issue a decision in EFSB 21 01 by the end of 2022, accompanied by a PIP and EFSB-specific LAP detailing implementation measures and timelines.

CHAPTER 7: GHG EMISSIONS FROM NON-ENERGY SOURCES & INDUSTRIAL USE

7.1 SECTOR OVERVIEW

Massachusetts has a relatively small industrial sector, which consumes electricity, natural gas, and petroleum to manufacture products, such as kilned ceramics, semiconductors, and some heavy equipment. Although emissions from industrial fuel use have been traditionally accounted for in the Buildings sector,[40] they have been separated for the purposes of this 2025/2030 CECP (as well as for the 2050 Roadmap Study) because the energy needs for manufacturing are fundamentally different from the comparatively low-temperature processes needed to heat and cool space and water in residential and commercial buildings. A combination of policies and economic factors have contributed to emissions from industrial energy use declining by about 20% since 1990.

Picture 15. Landscape with Industrial Waste Tower in Background

Non-energy emissions are 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: refrigeration, cooling and electrical switchgear; solid waste management, including landfills, composting and anaerobic digestion, and municipal waste combustion that does not generate electricity;[41] wastewater treatment, including septic tanks, wastewater treatment plants, and effluent management; natural gas transmission and distribution; agricultural practices; and non-combustion industrial processes. Current MassDEP estimates indicate that, in 2020, emissions from industrial energy use were no higher than 3.2 $MMTCO_2e$, approximately 5% of the Commonwealth's total gross emissions. MassDEP also estimates that the Commonwealth's emissions from other sources in 2020, including industrial process, were no higher than 4.7 $MMTCO_2e$, or about 7% of the Commonwealth's total gross emissions. The amount of this segment of GHG emissions have been effectively constant since 2005, though certain non-energy emissions subsectors have grown and declined during that time. The use and leakage of high-Global Warming Potential (GWP) hydrofluorocarbon (HFC) F-gases is the fastest-growing source of GHG emissions in Massachusetts. To meet aggressive decarbonization goals in the Commonwealth by mid-century, the Commonwealth needs to establish realistic pathways for emissions stabilization and reductions in this subsector using active management and best practices.

[40] The Massachusetts Annual GHG Emissions Inventory has included emissions associated with industrial energy consumption under the Buildings sector heading. However, industrial energy use differs substantially from the space and water heating demands that drive emissions in residential and commercial buildings and thus requires different decarbonization solutions.

[41] The Massachusetts Annual GHG Inventory includes municipal waste combustion for electricity generation in the electric sector, not the non-energy sector.

7.2 ACHIEVING 35% IN 2025 AND 48% IN 2030 IN THE INDUSTRIAL ENERGY AND OTHER SECTORS

In this decade, the Commonwealth will support and work to enact policies that will achieve flat (zero growth rate) industrial and non-energy GHG emissions through 2030 and put Massachusetts on a path for substantial emissions reductions from this sector of the economy by 2050. The main opportunity for substantial reductions in the 2020s involves new and strengthened regulations of F-gases.

GHG EMISSIONS SUBLIMITS FOR NON-ENERGY SOURCES

The 2025 GHG Emissions sublimit for Natural Gas Distribution and Service is 0.4 $MMTCO_2e$, or an 82% reduction from 1990 level. The 2030 GHG Emissions sublimit for Natural Gas Distribution and Services is also 0.4 $MMTCO_2e$, or an 82% reduction from 1990 level.

The 2025 GHG Emissions sublimit for Industrial Processes is 3.6 $MMTCO_2e$, or a 449% increase from 1990 level. The 2030 GHG Emissions sublimit for Industrial Processes is 2.5 $MMTCO_2e$, or a 281% increase from 1990 level. In March of 2022, EPA released an update to its methodology for estimating emissions from F-gases, the largest component of the emissions from Industrial Processes. Since estimates of future consumption and emissions of F-gases is consistent with the previous methodology, incorporating EPA's new methodology into Massachusetts' GHG Emissions Inventory may require updating forecasted F-gas emissions in the future. Table 7.1 below shows the historical levels of GHG emissions from natural gas distribution and services, as well as industrial process. It also shows the 2025 and 2030 GHG emissions limit set by this Plan for the two subsectors.

Table 7.1. GHG Emissions from Non-Energy Sources

Natural Gas Distribution & Services	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**
Gross Emissions ($MMTCO_2e$)	2.3	0.9	0.5	0.6	**0.4**	**0.4**
% Reduction (Increase) from 1990		62%	76%	74%	82%	82%
Industrial Processes	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**
Gross Emissions ($MMTCO_2e$)	0.7	3.7	4.1	3.1	**3.6**	**2.5**
% Reduction (Increase) from 1990		(457%)	(525%)	(372%)	(449%)	(281%)

Note: GHG emissions for 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

EEA is required to set individual sublimits for industrial processes, defined as the emission of CO_2, N_2O and F-gases in non-combustion processes, and natural gas leaks. However, combining other non-energy-related and industrial processes comprises a wide range of emissions sources that are distinct from the day-to-day energy uses considered in other sectors, such as heating one's home or driving a car. Thus, this category includes the GHG emissions of specialized F-gases used as refrigerants, the direct emissions of carbon dioxide as a result of lime production, and fugitive methane emissions from natural gas infrastructure, wastewater and solid waste disposal, and agricultural sources. In addition,

the emissions associated with the combustion of fossil fuels for other industrial needs has been included in this category.

Table 7.2. GHG Emissions Sublimits for Non-Energy Sources

Non-Energy & Industrial Gross Emissions	1990	2010	2015	2020	2025	2030
Industrial Energy	5.8	3.8	3.5	3.2	**2.9**	**2.5**
Natural Gas Distribution & Services	2.3	0.9	0.5	0.6	**0.4**	**0.4**
Industrial Processes	0.7	3.7	4.1	3.1	**3.6**	**2.5**
Agriculture & Waste	3.4	1.2	1.1	1.0	**1.0**	**0.9**
Total Gross Emissions ($MMTCO_2e$)	**12.1**	**9.6**	**9.3**	**7.9**	**7.9**	**6.3**
Total Percent Reduction from 1990		**20%**	**23%**	**34%**	**34%**	**48%**

Note: GHG emissions for 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

Below are the main policies and plans for 2025 and 2030 to achieve the above emissions requirements for the Natural Gas Distribution & Services and Industrial Processes. Because emissions from agricultural practices[42] and waste are very small and there are limited policy options to decrease them, this Plan does not include policies to lower these emissions further. For all other energy uses in industrial facilities, the Commonwealth is not setting any additional policies outside of reducing GHG emissions associated with building heat, which is covered in Chapter 5.

STRATEGY N1: TARGET NON-ENERGY EMISSIONS THAT CAN BE ABATED OR REPLACED

The most impactful strategy for the 2020s is to minimize the growth of non-energy emissions, particularly emissions of high-GWP gases associated with uses that are expected to grow through the next decade: HFCs used in refrigeration, air conditioners, and heat pumps, and SF_6 used in gas-insulated electrical infrastructure switchgear.

In December 2020, MassDEP promulgated regulations prohibiting the use of HFCs (310 CMR 7.76) in a broad range of existing end-uses. Through the 2020s, the Commonwealth will need to look at potentially expanding and strengthening that regulation to address additional end uses, like heat pumps, as they become more widely deployed. The Commonwealth's and other jurisdictions' HFC regulations typically apply only to new equipment, though leakage from such equipment occurs from manufacturing until decommissioning. To maximize the regulations' effect on emissions reductions by 2050, additional HFC regulations are best implemented as soon as possible. Additionally, the application of refrigerant-handling best practices when installing or removing equipment helps mitigate emissions associated with leakage. As the heat pump installation market ramps up in the next decade, there is an excellent opportunity to train the installation workforce in best practices for mitigating HFC emissions from the existing stock, as well as train them to work with zero and low-GWP alternative refrigerants. The

[42] This chapter does not include carbon dioxide emissions from agricultural practices, except for carbon dioxide emissions from urea fertilizers and liming. Methane and nitrous oxide emissions from agricultural practices are also included in this chapter.

development of 310 CMR 7.76 was coordinated with other states that participate in the U.S. Climate Alliance, and MassDEP will continue to work with these states to explore next steps for addressing HFC emissions, including possible regulations.

Congress enacted the American Innovation and Manufacturing (AIM) Act on December 27, 2020. The AIM Act directs EPA to phase down production and consumption of HFCs to 15% of their baseline levels in a stepwise manner by 2036 through an allowance allocation and trading program. On October 5, 2021, EPA finalized its first regulation under the AIM Act, setting the HFC production and consumption baseline levels from which reductions will be made and establishing an initial methodology for allocating and trading HFC allowances for 2022 and 2023.[43] In response to a variety of petitions submitted under the AIM Act, including one in which the Commonwealth joined the California Air Resources Board, EPA is developing regulations to both implement the prohibitions in 310 CMR 7.76 at the national level and further restrict the use of HFCs in specific sectors, including stationary refrigeration and air conditioning.[44] The Commonwealth will continue to engage with EPA and companies regulated under 310 CMR 7.76 during any future EPA rulemaking processes.

The continued and strengthened regulation of SF_6 leakage rates will similarly be valuable. MassDEP's Reducing Sulfur Hexafluoride regulation (310 CMR 7.72) requires newly-purchased electrical transmission equipment to have a low leak rate. Each utility's system-wide gas insulated switch gear SF_6 leakage must be reduced to 1% or less by 2020. This policy has been effective to reduce SF_6 to-date, though with expected growth in electrical distribution infrastructure, it likely will be valuable to revisit and potentially update this policy. California regulators have finalized requiring utilities to phase out the acquisition of new SF_6 gas-insulated switchgear and other electrical equipment.[45] This regulation also creates an incentive to encourage early replacement of all gas-insulated electrical equipment with technology that uses insulating gas with lower GWP than SF_6 or some alternative, zero-GWP technology. At present, the market for non-SF_6 equipment is immature, but as more jurisdictions set schedules for replacement, new options are expected to emerge.

Finally, methane leaks from the natural gas distribution network are substantial, but are being reduced significantly because of existing policies, most notably MassDEP's Reducing Methane Emissions from Natural Gas Distribution Mains and Services regulation (310 CMR 7.73). This existing regulation works with the gas distribution companies' Gas System Enhancement Plans (GSEPs) that are required by statute to ensure the replacement of leak-prone iron and unprotected steel pipes and services with newer, less leaky pipes. In addition to leaks from distribution system pipes, natural gas also leaks in small volumes from customer meters and customer-owned "behind the meter" piping and appliances. In the long-term policies to reduce the combustion of natural gas for space and water heating are likely to reduce the number of customers and total stock of gas system equipment and infrastructure, resulting in less methane leakage over time from behind the meter equipment.

[43] https://www.epa.gov/climate-hfcs-reduction/final-rule-phasedown-hydrofluorocarbons-establishing-allowance-allocation

[44] https://www.epa.gov/climate-hfcs-reduction/technology-transition-petitions-under-aim-act

[45] CARB. 2021. "Addendum to the Final Statement of Reasons for Rulemaking." Regulation for Reducing Sulfur Hexafluoride Emissions from Gas Insulated Switchgear. https://ww2.arb.ca.gov/rulemaking/2020/sf6 (retrieved 9 February 2022).

However, continued investments into the gas system while total consumption of pipeline gas decreases could result in significant gas rate increases. This dynamic is a key factor being investigated in DPU's Docket 20-80 on the Future of Gas and is discussed in Chapter 5. Through that docket, the DPU is seeking to develop a regulatory framework to guide the gas utilities and align with decarbonization efforts. Although Docket 20-80 has not yet been finalized, targeted decommissioning of the gas distribution system may be necessary to support a just and equitable transition toward electrified heating. For portions of the natural gas pipeline system that will not be decommissioned in the near term, natural gas utilities should evaluate options to reduce maintenance costs while still prioritizing reliability and safety. For example, in the future, gas utilities will need to assess the need for full replacement versus lower-cost repairs, minimizing additional capital investments and avoiding the risks of installing a brand-new asset which is likely to be stranded in the future. As a part of this 2025/2030 CECP, by the end of 2024, DPU will review and propose changes to the existing GSEPs for upgrades to leaky pipes that includes an economic evaluation of alternatives to full replacements in geographic areas with low anticipated natural gas utilization.

STRATEGY N2: IMPLEMENT BEST PRACTICES AROUND RESIDUAL NON-ENERGY EMISSIONS

For non-energy emissions, many of which are difficult or impossible to fully curtail and are expected to grow with the Commonwealth's human population, best practices can and should be established to keep them as low as possible.

The major source of emissions from solid waste disposal is the seven municipal waste combustors (MWCs) operating in the Commonwealth, which burn municipal solid waste to reduce the volume of disposed garbage while producing useful heat and electricity. Initial diversion of plastic, paper, and other incinerable materials from the waste stream—as called for in the Massachusetts 2030 Solid Waste Master Plan: Working Together Toward Zero Waste (SWMP)[46]—is expected to reduce GHG emissions from MWCs. Two long-range trends will affect the volume of disposed-of garbage by MWC facilities operating in Massachusetts. First, the Massachusetts 2030 SWMP articulates a commitment to the longer-term goal of reducing the Commonwealth's solid waste disposal to 4 million tons by 2030 and by about 90% (to 570,000 tons) by 2050, and diverting recoverable material from disposal to higher uses. On such a trajectory, Massachusetts would require less than its current MWC capacity to meet its solid waste management needs. Second, and consistent with its obligations to protect the environment and to help the Commonwealth comply with the GWSA, in the SWMP program review to be conducted in 2025, MassDEP will make a concerted effort to improve the performance of existing combustion capacity and analyze the potential approaches to reduce carbon dioxide emissions from municipal waste combustors, including capping the emissions from MWCs. MassDEP anticipates that any replacement MWC capacity would be required to meet tighter emissions and efficiency standards and increase separation of recyclable materials. Organics waste will be managed through technologies such as anaerobic digestion and composting, which will result in reduced GHG emissions.

For wastewater processing, there are opportunities to help stabilize emissions which are directly tied to population. Transitioning more residences from stand-alone septic systems to managed sewer systems would likely reduce methane emissions from septic tanks, as would encouraging (or requiring) septic

[46] https://www.mass.gov/guides/solid-waste-master-plan

system owners to follow best practices. Expanding the use of anaerobic digesters at wastewater treatment plants (WWTPs) would avoid many of the methane emissions from WWTPs and have the compounded advantage of converting sewage sludge into usable fuel. However, at this time, no additional policies are set in this plan to expand anaerobic digesters at WWTPs.

Picture 16. Allen Sheep Farm, Chilmark – Photo from MA Office of Travel & Tourism flickr site

For agricultural emissions, which are very small in Massachusetts, improved practices can contribute to emissions reductions or stabilization, as well as provide other benefits. In large agricultural states like California, agricultural emissions mitigation policies, practices, and technologies have been explored.[47] The Commonwealth has explored the potential for best practices to improve soils. Chapter 8 includes detailed plans to improve the carbon sequestration capabilities of our natural and working lands.

Since 1990, GHG emissions from the combustion of fossil fuels for industrial energy demands have fallen significantly. Much of this reduction is due to background trends, such as increasing globalization that has left fewer facilities operating within the borders of the Commonwealth. However, some of the decline is due to the deployment of high-efficiency equipment and the economical choice to switch away from expensive petroleum-based fuels where possible. Between 1990 and 2019, emissions from the combustion of petroleum products in the Commonwealth's industrial sector fell by 74%, while emissions from the combustion of natural gas have remained mostly flat. These trends are anticipated to continue, resulting in modest reductions in gross emissions by 2025 and 2030. In addition, in coordination with EPA laws covering air and water quality, MassDEP implements a range of regulations that protect the general public and the environment from damage resulting from industrial activities, including the Source Registration Program, which requires certain types of facilities and equipment to apply for permits and/or report annual emissions of pollutants. GHG emissions of certain industrial facilities are also reported to MassDEP pursuant to the GWSA. Meanwhile, EEA's Office of Technical Assistance (OTA) provides free, confidential, onsite technical assistance to Massachusetts manufacturers, businesses, and institutions looking to implement cost-effective strategies around toxics use reduction, resource conservation, energy conservation, and other sustainability goals. Both MassDEP and OTA will continue to monitor and advise industrial facilities on how best to reduce the emissions of a range of pollutants, many discussed above, that contribute to global warming or have other impacts on public and environmental health.

[47] CARB. 2020. "Research on Agricultural Emissions & Mitigation." Available at https://ww2.arb.ca.gov/research/research-agricultural-emissions-mitigation (retrieved 18 August 2020).

CHAPTER 8: PROTECTING OUR NATURAL AND WORKING LANDS

Massachusetts' natural and working lands (NWL) provide many benefits to the residents of the Commonwealth, including clean air and water, wildlife habitat, carbon sequestration, recreational opportunities, food and wood production, and many other functions on which society and life depend. These benefits, often called ecosystem services, continually serve our society as long as NWL can remain functioning as NWL. Massachusetts NWL ecosystems currently store at least 0.6 gigatons of carbon, equivalent to over 2 gigatons of carbon dioxide or the past 25 years of GHG emissions in the Commonwealth. As NWL are an important local resource to help remove carbon dioxide from the atmosphere, the Commonwealth will protect NWL from losses and degradation and will pursue new and ongoing actions to increase their capacity to sequester carbon.

Land use practices, land use change, and natural ecological processes all have implications for both carbon emissions and carbon sequestration on NWL in Massachusetts. This chapter of the 2025/2030 CECP lays out the plan for the Commonwealth to protect, better manage, and restore NWL, including reducing emissions, increasing sequestration, and securing carbon storage in NWL ecosystems and derived products.

Recognizing that the production of adequate housing, renewable energy deployment, jobs, and food and wood products often requires the use of land, this Plan for preserving NWL discusses ways to minimize the potential negative impacts on NWL while supporting sustainable population growth and consumption. This chapter presents new and ongoing actions the Commonwealth is pursuing to achieve net zero GHG emissions by 2050, including exploring additional carbon sequestration beyond the capacity of our NWL to sequester carbon. In addition, this chapter discusses policies to reduce emissions from wood harvest and processing.

NWL TERMINOLOGY

GHG flux: the rate of greenhouse gas released into (+) or removed (-) from the atmosphere from a particular source or sink per unit of land area (e.g., CO_2/hectare/year).

Net emissions: the sum of all GHG fluxes within a defined period and scope (e.g., net forest land emissions). NWL ecosystems simultaneously sequester CO_2 from the atmosphere and emit CO_2 back into the atmosphere (along with CH_4 and N_2O emissions in some cases).

Carbon sequestration: the process of removing CO_2 from the atmosphere and storing it in a carbon pool, i.e., the removal of CO_2 via photosynthesis and storage in NWL ecosystem carbon pools.

Carbon pool: a particular reservoir of carbon; usually a component of an ecosystem (e.g., forest soil carbon, wetland dead organic matter).

Carbon stock: the sum of all carbon pools within a defined area and time (e.g., Massachusetts forest carbon stock).

Carbon sink: the resources that store carbon.

8.1 OVERVIEW OF NWL IN MASSACHUSETTS

The 2021 Climate Law defines natural and working lands as "lands within the Commonwealth that: (i) are actively used by an agricultural owner or operator for an agricultural operation that includes, but is not limited to, active engagement in farming or ranching; (ii) produce forest products; (iii) consist of forests, grasslands, freshwater and riparian systems, wetlands, coastal and estuarine areas, watersheds, wildlands or wildlife habitats; or (iv) are used for recreational purposes, including parks, urban and community forests, trails or other similar open space land."[48]

Consistent with IPCC guidelines,[49] Massachusetts separates NWL into four categories, representing the major land classes in the Commonwealth: (a) forest lands, (b) settlements, (c) wetlands, and (d) croplands & grasslands. Figure 8.1 below shows the spatial distribution of these land classes in 2020.[50] Forest land covers approximately 2.9 million acres or 57% of Massachusetts, settlement land covers 1.3 million acres (~25%), wetlands and water cover 0.5 million acres (~10%), and croplands and grasslands cover 0.4 million acres (~7%).[51] Within each class of land, a variety of subclasses represent distinct ecosystems and land cover or uses (e.g., coastal and freshwater wetlands), as well as different ecosystem carbon pools and fluxes (e.g., vegetative biomass, biomass growth, and soil).

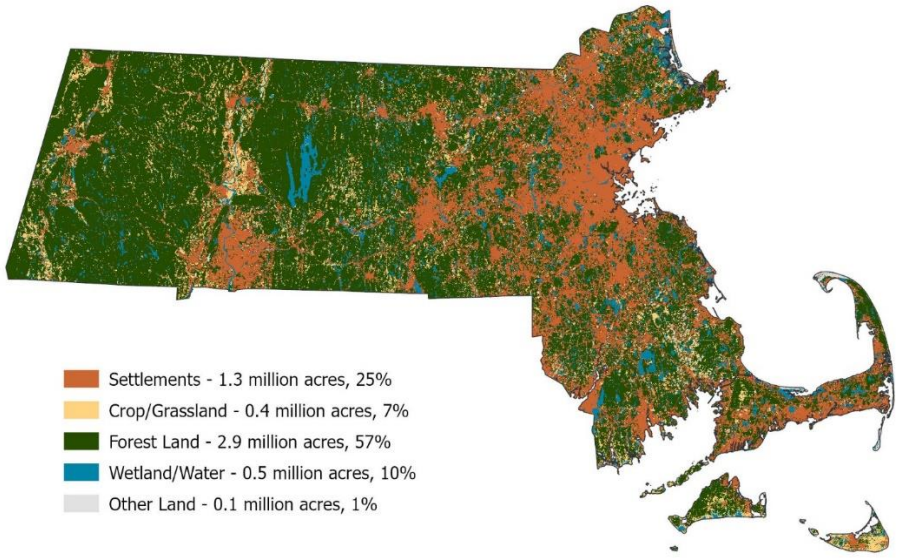
[48] Chapter 8 of the 2021 Climate Acts, Section 4.

[49] IPCC. 2006. Volume 4: Agriculture, Forestry, and Other Land Use Volume 4: Agriculture, Forestry, and Other Land Use - 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme. IGES, Japan.

[50] This information is based on EEA's modification to the land cover products from the U.S. Geological Survey (USGS) Land Change Monitoring, Assessment, and Projection (LCMAP) Collection 1.2., available at https://www.usgs.gov/special-topics/lcmap/collection-12-conus-science-products.

[51] Different definitions, classifications, data sources and approaches can lead to different estimates of land cover or land use. For instance, estimates of forest land in Massachusetts range from 50 to 75%. For the purpose of this plan, forest land is defined as land at least one acre in area that supports at least 10% tree cover (or is regenerating this level of tree cover) and is not otherwise subject to settlement or agricultural land use. EEA is developing a land classification approach to consistently estimate land use and land use change statewide for the purposes of its NWL planning, with the initial version used to produce Figure 8.1. See Appendix C for further details.

Figure 8.1. Map of Massachusetts' Natural and Working Lands in 2020, Grouped into Four Major Land Classes



Effectively, our NWL is made up of lands, trees, other vegetation, soils, and microbes. These resources capture and release carbon dioxide naturally as part of the carbon cycle, storing it as carbon compounds in biomass and soils. Trees and other vegetation remove carbon dioxide from the atmosphere through photosynthesis when adequate light and water are available and transfer carbon below ground into roots and the soil. Soils, trees, and other vegetation also emit carbon dioxide back into the atmosphere through respiration and microbe-facilitated decomposition of dead organic matter. This natural exchange of carbon between the atmosphere, trees and vegetation, microbes, and soils can be disturbed or enhanced by natural events (e.g., hurricanes) and/or human activities. The type of activities and their frequency can directly and indirectly affect the condition of the impacted sites. Regionally, the amount of carbon dioxide removed and stored in NWL has generally been greater than the amount emitted by NWL for the past century, though natural and anthropogenic disturbances can lead to land becoming local net emissions sources. Because of their dynamic nature, the accounting of NWL GHG emissions—how much emissions are in the baseline, how much emissions to reduce, and how much can be stored in NWL—is very different from the way one typically thinks about the accounting of GHG emissions from the combustion of fossil fuels used in heating, transportation, electric generation, and other processes (e.g., gasoline cars, oil boilers, and gas furnaces), as those activities do not continually remove and store carbon like in the NWL carbon cycle.

In 2021, EEA began improving the methods used to track the statewide inventory of GHG flux from and on NWL. This work is based on the latest available science and statewide tools (see Appendix C for more information about this process and methodology). The initial results of this improved NWL GHG inventory indicate that Massachusetts' NWL sequestered approximately 7.0 $MMTCO_2e$ in 2019, the latest year with available statewide data, as shown in Table 8.1. This value does not yet include GHG flux from inland wetlands. EEA will continue to improve the NWL GHG inventory as new data sources and innovative approaches become available.

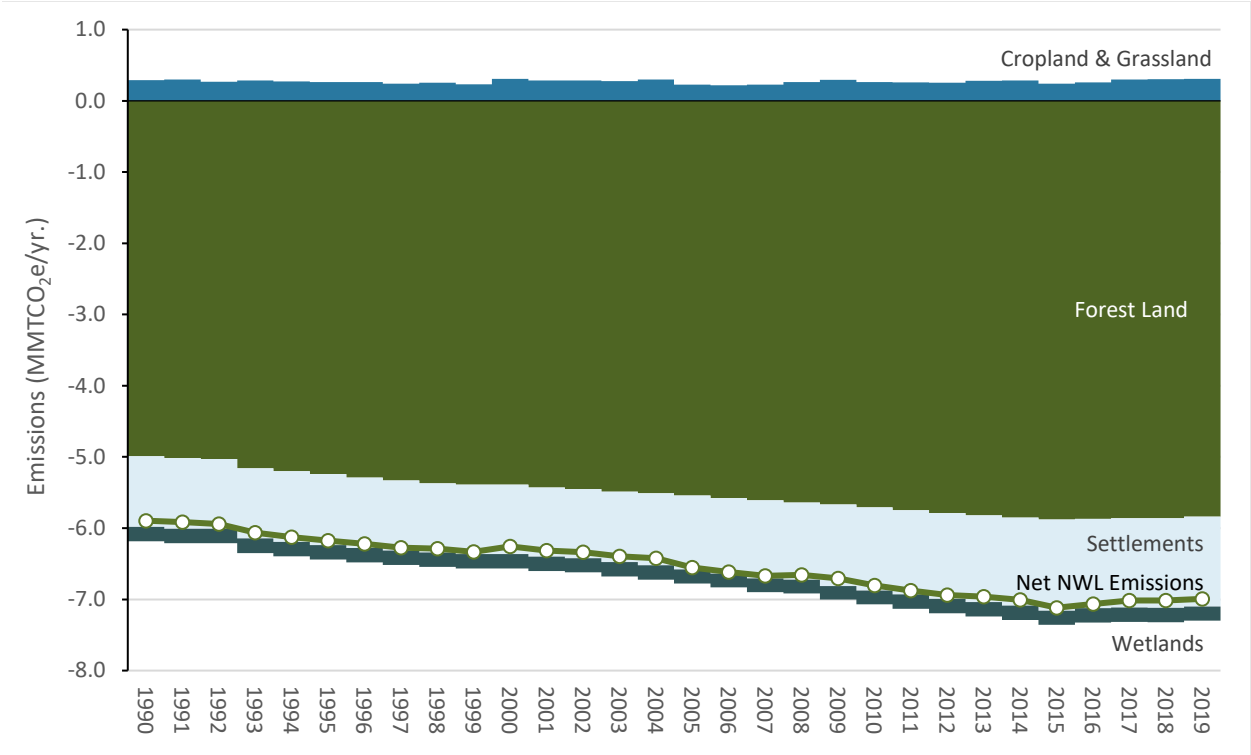
Table 8.1. Preliminary Inventory of Estimated GHG Emissions (positive values) and Sequestration (negative values) in 2019 by Major NWL Land Classes in Massachusetts

Land Classes / Reporting Categories	Net Emissions ($MMTCO_2e$/year) 2019
Forest Land	**-5.8**
Forest Ecosystem	-4.6
Harvested Wood Products	-0.7
New Forest Land	-0.6
Cropland & Grassland	**0.3**
Wetlands	**-0.2**
Coastal Wetlands	-0.2
Inland Wetlands	TBD
Settlements	**-1.3**
Settlement Biomass	-2.7
Settlement Soils	0.9
New Settlement Land	0.5
Net NWL Emissions	**-7.0**

Note: Subtotals shown may not sum to the total due to rounding.

As shown in Figure 8.2 below, the annual rate of net NWL sequestration (negative net NWL emissions) has been increasing since 1990 until the past five years, when it appears to have plateaued. This rate is equivalent to approximately 10% of the Commonwealth's gross emissions in 2019 and roughly half of allowable residual emissions in 2050. This means, based on the current estimate, the Commonwealth likely would need to further decrease the level of GHG emissions from the economy to beyond an 85% reduction and/or secure additional carbon sequestration from our NWL, or by other means, to achieve net zero GHG emissions in 2050. The management of NWL to increase carbon sequestration in the short term must be balanced against other ecosystem services that NWL provide and the long-term health and resilience of the state's NWL.

Figure 8.2. Inventory of Estimated Annual Carbon Emissions and Sequestration by Major NWL Land Classes in Massachusetts



FOREST LAND

Over 50% of Massachusetts is categorized as forest land, with many of these forest lands located in the central and western regions of the Commonwealth. As shown in Table 8.1 and Figure 8.2 above, based on current estimates, 82% (5.8 $MMTCO_2e$ per year) of NWL carbon sequestration occurs on forest land. The annual 5.8 $MMTCO_2e$ includes the carbon sequestration from existing forests (approximately 4.6 $MMTCO_2e$ sequestered annually), new forest land from afforestation and reforestation (0.6 $MMTCO_2e$ sequestered annually), and the carbon transfer from live trees into harvested wood products (0.7 $MMTCO_2e$ sequestered annually). Approximately 0.6 $MMTCO_2e$ is emitted each year from the conversion of forests to other land uses, primarily through development for settlement uses.[52] Protecting forest lands from conversion will preserve both existing forest carbon stocks and the capacity of forest ecosystems to continue sequestering carbon dioxide in the future.

[52] For GHG reporting purposes, these emissions are attributed to the land use classes that forest land is converted to (e.g., emissions from forest land converted to settlement uses is reported as a settlement emission).

Management of forest lands is necessary for the Commonwealth and its residents to benefit from continued carbon sequestration and other ecosystem services. Like many temperate forests throughout the world,[53] those in Massachusetts have been regrowing due to natural regeneration and forest conservation practices following a land use history of forest clearing for agriculture and extractive logging until the late nineteenth century. As shown in Figure 8.2 above, the regrowth has been providing a steady increase in forest carbon sequestration since 1990. However, this net carbon sequestration rate is showing signs of slowing down (see Appendix C for preliminary assessment of net NWL carbon sequestration rate). Additionally, between 1985 and 2019, timber harvest declined by 62%, while carbon stock in forests increased 66%, and natural mortality (not harvest removals) increased over 200%.[54, 55] As more severe weather events occur and as invasive species increase competition for nutrients and bring illnesses, those affected forest lands risk becoming a net source of emissions without climate-smart forest management to sustain carbon sequestration and increase their resilience over the long term.

Picture 17. Mt. Norwottuck – Granby. Photo credit: Lynne Graves

Efforts to protect forest lands from conversion and improve management practices must address publicly and privately-owned forests and must balance a range of uses because more than 65% of Massachusetts' forests are privately owned, including by private citizens and nongovernmental organizations (NGOs) such as land trusts.[56, 57] While NGOs own and manage a significant portion of private forests, the majority are owned by over 200,000 private landowners across the Commonwealth. Private landowners use the forests for diverse reasons, including to produce wood and other forest products and to enjoy natural beauty, privacy, natural resource value, investment potential, and personal recreation. Massachusetts' policies around forest protection are aimed at helping private

[53] Cook-Patton, S.C., Leavitt, S.M., Gibbs, D. *et al.* Mapping carbon accumulation potential from global natural forest regrowth. *Nature* 585, 545–550 (2020). https://doi.org/10.1038/s41586-020-2686-x

[54] Analysis of net merchantable bole volume of growing-stock trees (at least 5 inches diameter at breast height), in cubic feet, on remaining timberland using data from 1) Dickson, David R.; McAfee, Carol L. 1988. Forest Statistics for Massachusetts--1972 and 1985. Resour. Bull. NE-106. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 112 p., available at https://doi.org/10.2737/NE-RB-106; 2) USDA Forest Service's Forest Inventory and Analysis Database, available at https://www.fia.fs.fed.us/tools-data/; 3) Northeastern Forest Experiment Station 1956. The Timber Resource in Massachusetts. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 45 p., available at https://www.fs.usda.gov/treesearch/pubs/22951.

[55] Another data source indicates total forest ecosystem carbon stock has increased 12% and live tree carbon stocks increased 28% between 1990 and 2020. Walters et al. 2021. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2019: Estimates and quantitative uncertainty for individual states. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2021-0035

[56] Massachusetts Forest Action Plan, published December 2020. Available at https://www.mass.gov/service-details/massachusetts-forest-action-plan.

[57] Butler et al., "The Forests of Southern New England, 2012 A Report on the Forest Resources of Connecticut, Massachusetts, and Rhode Island," *U.S. Department of Agriculture, Forest Service, Northern Research Station*, 2015, 1–42.

landowners continue to keep their forests as forests and manage their forest land for resilient carbon storage.

The state owns over 525,000 acres of forest lands, and manages them for wildlife habitat, water supply protection, public recreation, the production of wood and other forest products, and the demonstration of sustainable forestry. The Department of Fish and Game (DFG) owns and manages over 143,000 acres of forest lands, including Wildlife Management Areas and Wildlife Sanctuaries. The Division of State Parks and Recreation and the Division of Water Supply Protection of the Department of Conservation and Recreation (DCR) are responsible for the stewardship and management of nearly 377,000 acres of forest lands. Over 111,000 acres of these forest lands were designated in 2012 as Forest Reserves—the least fragmented forested areas where ecological processes predominate and inform management, and where commercial timber harvesting is not allowed except under very narrow circumstances and after extensive review. About 77,000 acres were designated as Parklands—areas focused on the protection and appreciation of natural and cultural resources that provide public recreation opportunities and a place to connect with nature. The rest, roughly 122,500 acres, were designated as Woodlands—forested areas managed for forest health, resource protection, sustainable production of timber, and recreation. The *Landscape Designations for DCR Parks & Forests: Selection Criteria and Management Guidelines*, published in March 2012, has more information about the management activities allowed in each of these landscape designations.[58] More information on the ownership and protection status of remaining forest lands, as well as a comprehensive assessment of forests in the Commonwealth, is available in the *Massachusetts Forest Action Plan*, released in December 2020.[59]

Ensuring that our forests continue to provide the full range of ecosystem services in the face of ongoing climate change requires careful stewardship that considers forest ecosystem dynamics, protections against forest loss, and sustainable harvest and use of forest products. While carbon sequestration is among the most important forest ecosystem services in the context of this 2025/2030 CECP and the Commonwealth's ability to achieve net zero in 2050, forests must also continue to provide wildlife habitat, wood products, clean air and water, and recreation, necessitating tradeoffs in which ecosystem services are prioritized in forest management.[60, 61] These management decisions must be tailored to the particular ecological conditions, land owners' objectives, and community values for specific forest areas. It may be appropriate to leave some forests unmanaged or with minimal management to fulfill the role of wildlands. In other cases, some level of forest management will help ensure that forests are healthy, resilient to ecological disturbances, and able to continue providing a balance of ecosystem services, including long-term carbon sequestration and storage. For example, efforts to remove invasive species and less vigorous trees, and to thin overstocked forests allow remaining trees to benefit from less competition for resources and grow more quickly. Climate smart management approaches can also help forests be less susceptible to damage from ecological disturbances exacerbated by climate change and

[58] Available at https://www.mass.gov/doc/landscape-designations/download.
[59] Available at https://www.mass.gov/service-details/massachusetts-forest-action-plan.
[60] Woodall, Christopher W.; D'Amato, Anthony W.; Bradford, John B.; Finley, Andrew O. 2011. Effects of stand and inter-specific stocking on maximizing standing tree carbon stocks in the eastern United States. Forest Science. 57(5): 365-378. Available at https://www.fs.usda.gov/treesearch/pubs/39406.
[61] Littlefield, A.W. and D'Amato, C.E. Identifying trade-offs and opportunities for forest carbon and wildlife using a climate change adaptation lens. Conservation Science and Practice, 2022(4). Available at https://doi.org/10.1111/csp2.12631.

ensure that disturbed forests are able to recover more quickly. When necessary and appropriate to remove trees, utilizing the wood in long-lived, durable products will help minimize emissions and maximize stored carbon. While there is not one single policy that will uniformly cover all of Massachusetts forests, the Commonwealth's primary strategy for NWL to help achieve net zero GHG emissions is to keep our forest lands remaining and functioning as forest lands.

SETTLEMENT LAND, TREES, AND FORESTS

Massachusetts has 1.3 million acres of settlement land (i.e., developed land; 25% of total area) that includes impervious surfaces, patches of urban forests, and developed open space (e.g., lawns, gardens, and landscaping found in residential areas, commercial and institutional campuses, parks, and golf courses). Collectively, net carbon sequestration on settlement lands was approximately 1.3 $MMTCO_2e$ in 2019.

Significant opportunities exist to increase the carbon sequestration potential on settlement lands, including tree planting on the 0.4 million acres of developed open space in the Commonwealth that currently lack canopy cover.[62] A recent study found that urban forests are storing more carbon than previously estimated due to having more access to sunlight and nutrients than forests in non-urban areas.[63] Additionally, urban tree planting on lawns and turf not only provide carbon sequestration aboveground but also improve the soil organic carbon content (i.e., soil carbon storage).[64]

While this 2025/2030 CECP focuses on the value of our trees and forests for carbon sequestration and storage, the health and other benefits they provide are also valuable. Urban forests and trees provide clean air and water, storm water retention, and habitat for birds and other wildlife. They also provide cooling shade and block wind, helping to reduce the cooling and heating needs of adjacent buildings. Urban forests provide outdoor recreation and a direct connection to nature to surrounding communities, which has been shown to be very valuable as more people turned to outdoor, nature walks during the COVID-19 pandemic. Appendix D further discusses the health and other benefits of urban tree planting.

Picture 18. Paul Revere Park, Massachusetts. Photo Credit: MA Office of Travel & Tourism flickr site

[62] Estimate of acres of recreational and ornamental landscape is based on the 2016 Land Cover/Land Use dataset from MassGIS, available on https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use.
[63] Morreale, L.L., Thompson, J.R., Tang, X. et al. Elevated growth and biomass along temperate forest edges. *Nat Commun* 12, 7181 (2021). https://doi.org/10.1038/s41467-021-27373-7
[64] Literature review found that, when trees are present in lawns and turf, soil organic carbon content is 20% higher than in turf alone.

WETLANDS

The wetland land class, which includes open water, emergent herbaceous, scrub/shrub, and forested wetlands in both inland and coastal environments, accounts for 0.5 million acres (10%) of land cover in Massachusetts. About 93% of all wetlands are classified as non-tidal freshwater, while the rest are tidal wetlands that include carbon-rich salt marshes. Wetland function is dependent on a particular set of hydrologic conditions that continue to be threatened by land use alteration and climate change, such as rising sea levels and more severe storms. Protecting wetlands and their functional integrity is a critical component of Massachusetts' climate strategy. Wetland alterations (e.g., fill and loss of wetlands) and disturbance (e.g., flow restriction, stormwater runoff) can result in carbon release as methane gas, a GHG that is 28-36 times more potent than carbon dioxide.[65]

Picture 19. Blackstone River Valley National Heritage Corridor: Uxbridge. Photo credit: Carol Dandrade

According to the analysis of wetlands status and trends conducted by MassDEP,[66] the biggest changes to freshwater wetlands are land use alterations from beaver and human activities. Beavers are known to significantly alter their landscape by creating dams upon which they can build their lodge protected from predators. Beaver-created dams flood surrounding land, creating new wetlands and changing the hydrology of the surrounding areas. Beaver activities, particularly in central Massachusetts, created about 2,400 acres of new freshwater wetlands and changed about 12,900 acres of existing freshwater wetlands to other types (e.g., forested to shrub or emergent) between 1990 and 2005.

Natural disturbances like beaver activities underscore the dynamic nature of freshwater wetland ecosystems and their potential to be either a source of GHG emissions or a sink of carbon—sometimes alternating between both within a year or season. Human activities, on the other hand, can be limited to reduce the risks of wetlands being a source of GHG emissions. MassDEP identified over 1,500 acres of wetland resource (mainly wooded swamps, marshes, or shrub swamps) that were lost due to human activities between 1990 and 2005. MassDEP's Wetland Change Project found that the greatest cause of wetland resource loss due to human activity has been residential and commercial development.[67]

[65] Methane is estimated to have a global warming potential of 28–36 over 100 years, but a global warming potential of 84-87 (i.e., 84-87 times more potent than carbon dioxide) over 20 years.
[66] MassDEP's *Inland and Coastal Wetlands of Massachusetts: Status and Trends* report, March 2019. Available at https://www.mass.gov/doc/inland-and-coastal-wetlands-of-massachusetts-status-and-trends/download.
[67] MassDEP's *Inland and Coastal Wetlands of Massachusetts: Status and Trends* report, March 2019. Available at https://www.mass.gov/doc/inland-and-coastal-wetlands-of-massachusetts-status-and-trends/download.

For salt marshes, sea level rise, nutrient pollution, reduced sediment supply, and flow alterations have been identified as important stressors.[68] If sea level rises beyond the capacity of a salt marsh to keep pace by building vertically through natural processes, the marsh will begin to break down, resulting in a loss of ecosystem services and associated carbon stocks. While marshes bordering suitable lands may be able to migrate horizontally in response to sea level rise in a process called marsh migration, in many coastal areas the presence of development and steep topography can create a barrier, inhibiting this process. Sea level rise could also result in the migration of tidal wetlands into adjacent brackish and freshwater wetlands. The Massachusetts Office of Coastal Zone Management applies the Sea Level Affecting Marshes Model (or SLAMM) to examine the current and potential future extent and distribution of coastal wetlands in response to sea level rise, including areas of potential marsh migration.

Permanently protecting marshes, the surrounding buffer, and salt marsh migration areas is important to preserving wetlands, in addition to land use planning and practices that maintain connectivity and limit non-point source pollution. Restoration of tidal flow in salt marshes by removing restrictions and upsizing culverts can support the reduction of methane emissions and increase carbon storage while also supporting the ecological function and resiliency of the marsh.[69, 70]

The Division of Ecological Restoration at DFG has been initiating projects throughout the Commonwealth that restore rivers, streams, wetlands, and watersheds. The Division partners with other state agencies and offices (e.g., Office of Coastal Zone Management), nonprofits, towns, individuals, and groups to implement pro-active restoration projects. They continue to support research on emerging innovative restoration methodologies to restore tidal flows and ecological functions to wetlands.

CROPLANDS & GRASSLANDS

Agricultural land and grasslands constitute a relatively small part of Massachusetts' land area (about 0.4 million acres or 7% of MA land area), but agriculture is an important focus area for reducing GHG emissions[71] and increasing carbon storage. About 205,800 acres are classified as agricultural land as of 2016 using high resolution combined land use/cover data.[72] Agricultural land can be subdivided into annual cropland (29%), perennial cropland (6%), and pasture/hayland (65%).[73] Per-acre carbon stocks

[68] Pappal, A. and K. Kahl. 2022. Gaining Ground: Defining Priority Research for Resilient Salt Marshes. Salt Marsh Working Group, a working group of the Massachusetts Ecosystem Climate Adaptation Network.
[69] Wang, F., Eagle, M., Kroeger, K.D, Spivak, A.C., Tang, J. Plant biomass and rates of carbon dioxide uptake are enhanced by successful restoration of tidal connectivity in salt marshes. Sci. Total Environ 750, 141566 (2021). https://doi.org/10.1016/j.scitotenv.2020.141566
[70] Kroeger, K., Crooks, S., Moseman-Valtierra, S., Tang, J. Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention. Sci. Rep.7, 11914 (2017). 10.1038/s41598-017-12138-4. https://doi.org/10.1038/s41598-017-12138-4
[71] This chapter addresses carbon dioxide emissions from agricultural soil management and ways to keep and increase carbon in storage soils (i.e., lower carbon dioxide emissions). It does not address carbon dioxide emissions from urea fertilizer and lime applications on soils, methane emissions from enteric fermentation, methane and nitrous oxide emissions from manure management and applications on soils, or nitrous oxide emissions from agricultural soil.
[72] 2016 Land Cover/Land Use dataset from MassGIS, available on https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use.
[73] Data for the year 2020 from the USDA's National Agricultural Statistics Service Cropland Data Layer.

(both aboveground carbon storage in vegetation and below-ground carbon storage in roots and soils) are highest in perennial cropland, followed by pasture/hayland, with annual cropland having the lowest carbon stocks due to not having vegetative cover during part of the year. Increasingly, Massachusetts farmers are adopting and implementing healthy soils practices through use of annual cropping systems that combine cover crops, reduced tillage, and crop rotation. Despite this, Massachusetts' preliminary NWL GHG inventory indicates that croplands in Massachusetts, including land conversion to croplands and grasslands, are emitting about 0.3 $MMTCO_2e$ per year more than they are sequestering. Like forests, management practices are important factors that affect whether agricultural soils are a net source or sink of carbon.

In addition to the importance of management practices influencing the carbon footprint of agriculture, protection of farmland from conversion to development can prevent soil carbon loss. The proximity of many farms to roads and growing towns exposes agricultural land and soil to the risk of residential and commercial development. Between 2001 and 2016, approximately 14,300 acres of Massachusetts' farmland were converted to urban and highly developed use, while about 12,800 acres were considered threatened by low-density residential development.[74] Permanently protecting farmland, along with the implementation of healthy soils practices, are the best ways to prevent carbon losses from land conversion.

Picture 20. Fields at Saltbox Farm – Concord. Photo credit: Saltbox Farm

The Commonwealth is currently developing a Farmland Action Plan to accelerate the protection of farmland through 2050. The plan will outline goals and recommendations, and provide a roadmap to overcome challenges and increase farmland protection, farmland access, food security, and the long-term economic and environmental viability of farms across all regions of the state. The plan will include the following components:

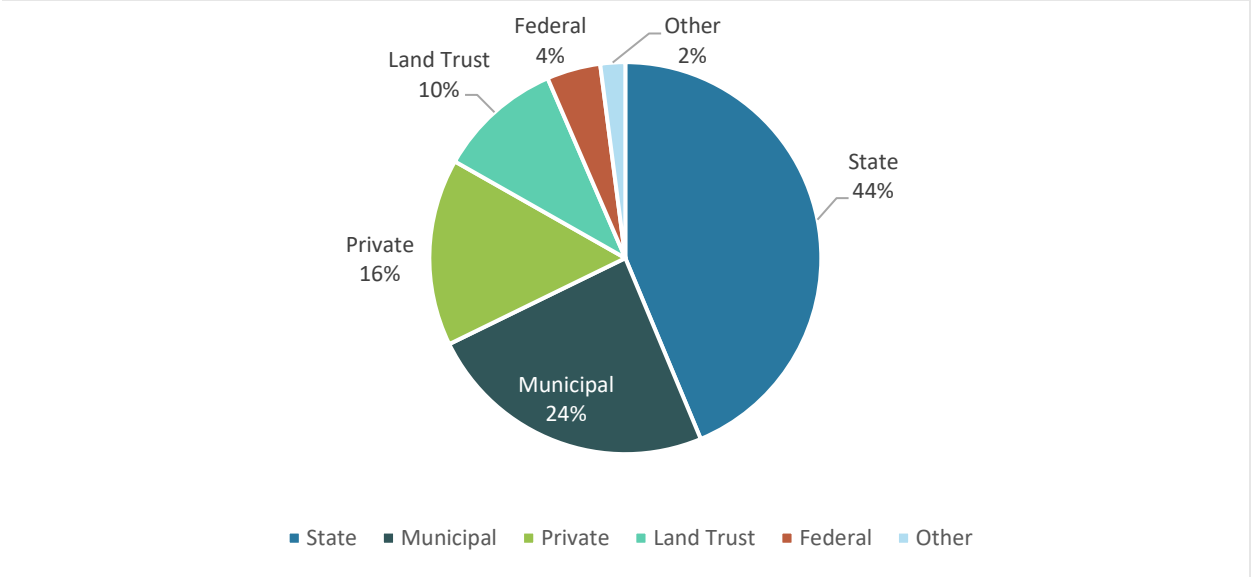
- Identify a multi-year strategy for increasing farmland protection through 2050.
- Set measurable goals related to farmland protection, farmland viability, and social justice for all populations, including historically underserved or disenfranchised populations in the agricultural sector.
- Recommend strategies and state spending and resources needed to meet the above goals.
- Create measurement tools to track progress.

[74] American Farmland Trust's *Farms Under Threat: State of the States* report, released 2020. Available at https://farmlandinfo.org/publications/farms-under-threat-the-state-of-the-states/.

8.2 GOALS FOR NATURAL AND WORKING LANDS FOR 2025 AND 2030

Given the importance of NWL in providing ecosystem services and helping the Commonwealth achieve net zero GHG emissions by 2050, it is imperative that the state's NWL retain their function and are protected from conversion and degradation. Based on the latest available data of protected and recreational open space land,[75] approximately 1.4 million acres (or about 27% of Massachusetts land and water) of undeveloped land in Massachusetts is permanently protected from development through outright ownership, conservation restrictions, agricultural preservation restrictions, watershed preservation restrictions, and other deed restrictions. A little less than half of the 1.4 million acres of protected undeveloped land are owned by the state, with cities and towns owning almost a quarter; the rest is owned by private entities, land trusts, federal agencies, and other entities (including conservation organizations, other non-profit organizations, and counties). Figure 8.3 below has more details on the breakdown of ownership.

Figure 8.3. Ownership of Permanently Protected Open Space, as listed in the MassGIS's Protected and Recreational OpenSpace data



To retain NWL carbon sequestration capacity for 2050 and prevent further emissions, the Commonwealth is committing, through state conservation efforts, to the goal of **increasing permanent conservation of undeveloped land and water (including wetlands) in Massachusetts to at least 28% and 30% by 2025 and 2030, respectively.** These goals translate to approximately 63,400 acres through 2025 and more than 167,000 acres through 2030 that will be conserved or permanently protected from

[75] Protected and Recreational OpenSpace Datalayer available on https://www.mass.gov/info-details/massgis-data-protected-and-recreational-openspace. The US Environmental Protection Agency defines open space as any open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public, including land that is partly or completely covered with grass, trees, shrubs, or other vegetation; schoolyards; playgrounds; public seating areas; public plazas; and vacant lots.

development. The goal for 2030 is consistent with the national policy contained in the "Conserving and Restoring America the Beautiful"[76] initiative to conserve 30% of the country's lands and waters by 2030.

In addition to NWL conservation, the Commonwealth will aim to reduce GHG emissions and enhance carbon sequestration on NWL through better management and restoration with a commitment to the following goals:

- **Incentivize 20% of privately owned forests and farms to adopt climate smart management practices by 2030** that balance increasing carbon sequestration and storage with increasing resilience to disturbances from invasive species, pests, and climate change.
- **Plant at least 5,000 acres and 16,100 acres of new urban and riparian trees by 2025 and 2030 respectively,** to increase carbon sequestration and provide urban cooling, stormwater management, and other ecosystem services.
- **Achieve no net loss of stored carbon in wetlands by 2030,** ensuring not only no net loss of wetlands, but also the conservation of their ecological and carbon storage functions.
- Incentivize increased utilization of harvested wood in long-lived durable products, reaching a 5% improvement between 2025 and 2030 in durable wood product recovery of harvested timber. This will help lower emissions from timber harvest and processing and extend the storage of harvested carbon in long-lived wood products.

EEA will also work with DCR, DFG, and other state entities to collaborate on management goals and strategies for state-owned forests that are consistent with the Commonwealth's NWL goals and strategies. At the time of the 2025/2030 CECP publication, DCR is revisiting the landscape designations of forests managed by DCR's Division of State Parks and Recreation. Management goals will be developed as part of that review, which includes a dedicated public and stakeholder engagement process. EEA has also retained the researchers behind the *Land Sector Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study*[77] to update and expand their analysis of forest management and its impacts and benefits to carbon sequestration. EEA will share the results from the updated analysis with state agencies to inform forest management practices on state forests the agency owns and manages.

Success in achieving these goals will allow the Commonwealth to reduce the rate of NWL conversion and emissions while permanently conserving ecosystem function and increasing net carbon sequestration on NWL. Acknowledging that NWL GHG fluxes are complex, dynamic, and uncertain (see Appendix C), and that natural disturbances pose some risk to current carbon stocks, Massachusetts is committing to the goals of **maintaining the current level of NWL net emissions through 2025 (estimated at -7.0 MMTCO$_2$e per year) and achieving a net NWL emissions reduction of 25% below 1990 level by 2030 (estimated at -7.4 MMTCO$_2$e per year)**, as listed in Table 8.2. Achieving these goals will put Massachusetts on a path to reach net zero GHG emissions in 2050 and rely less on carbon

[76] Available at https://www.doi.gov/sites/doi.gov/files/report-conserving-and-restoring-america-the-beautiful-2021.pdf.
[77] Released in December 2020. Available https://www.mass.gov/doc/land-sector-technical-report/download .

sequestration from outside our borders. The next section outlines the key strategies, policies, and actions to achieve these goals.

Table 8.2. Preliminary Estimate of Emissions from Natural and Working Lands

NWL	1990	2010	2015	2020	2025	2030
Net Emissions ($MMTCO_2e$)	-5.9	-6.8	-7.0	-7.0*	**-7.0**	**-7.4**
% Reduction (Increase) from 1990	-	15%	19%	19%*	19%	25%

* Estimated from 2019 data, as data for 2020 are not yet available

Note: Net emissions from inland wetlands not yet accounted for.

8.3 STRATEGIES AND POLICIES FOR NATURAL AND WORKING LANDS

The comprehensive suite of strategies, policies, and actions presented in this section (NWL Plan) will facilitate the achievement of the bold but achievable goals set in the previous section. This NWL Plan was developed based on planning efforts related to resilient lands and healthy soils policies as well as the 2020 Forest Action Plan,[78] and was informed by stakeholders through various technical meetings and public sessions conducted between the release of the Interim 2030 CECP and the finalization of this 2025/2030 CECP (see Appendix F for more information on the public process). In addition, this NWL Plan is consistent with the most recent national policy contained in President Biden's Executive Order 14072: Strengthening the Nation's Forests, Communities, and Local Economies,[79] signed on Earth Day 2022.

This NWL Plan focuses on strategies that protect and enhance our existing carbon storage capabilities and ensure its resilience through and beyond 2050. The strategies include:

1. **Protect NWL:** Keep NWL as NWL to protect current capacity for ongoing and future carbon sequestration.
2. **Manage NWL:** Enhance carbon sequestration and improve ecosystem resiliency to reduce risks of carbon loss from climate change and ecological disturbances.
3. **Restore NWL:** Reduce emissions and increase carbon storage capacity in NWL.
4. **Incentivize long-lived durable wood products:** Extend carbon storage as a part of climate-smart forest management and support for the local NWL-based economy.
5. **Explore additional carbon sequestration:** Achieve net zero GHG emissions by 2050 with carbon dioxide removal and storage beyond the capacity of Massachusetts NWL.

[78] *Massachusetts Forest Action Plan*, published December 2020. Available at https://www.mass.gov/service-details/massachusetts-forest-action-plan.
[79] https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/

STRATEGY L1: PROTECT NWL (KEEP NWL AS NWL)

Protecting the NWL current capacity for ongoing and future carbon sequestration is the universally accepted and most important strategy for the Commonwealth. This strategy requires a two-pronged approach: (1) proactive and strategic expansion of NWL conservation efforts to keep more NWL as NWL and for as long as possible, and (2) reduction in NWL conversion that reduces direct emissions and the loss of future carbon sequestration.

Expand Landscape and Watershed-Scale Conservation

The Commonwealth, land trusts, and other conservation organizations have diligently conserved 27% of open space in Massachusetts thus far. To permanently conserve at least 28% and 30% of undeveloped land and water (including wetlands) through state conservation efforts by 2025 and 2030, respectively, the Commonwealth aims to double the state's current pace of NWL conservation of ~10,000 acres per year to 21,000 acres per year.[80] Below are specific policies and actions that the state agencies will implement.

Picture 21. Mohawk Trail. Photo credit: Eugene Michalenko

- By the end of 2023, EEA and associated agencies will review and update evaluation criteria of state land acquisitions and land conservation programs to **prioritize protection of forests vulnerable to development, carbon-rich forests, wetlands, and open space upstream of wetlands, including marsh migration corridors**.
- EEA will seek to **increase the annual budget of land protection grants and programs through state and federal funding sources** (e.g., Land and Water Conservation Fund). Governor Baker filed An Act Investing in Future Opportunities for Resiliency, Workforce, and Revitalized Downtowns (FORWARD) on April 21, 2022, that includes $4 million of the American Rescue Plan Act (ARPA) funding to be used for open space acquisition. With increased funding, EEA can expand the budget for the existing Landscape Partnership conservation program to encourage multi-parcel projects across municipal boundaries that conserve whole habitat or watershed systems; administer new grants that focus on landscape conservation in important water supply watersheds, many of which are in rural communities and supply drinking water to Gateway Cities; raise the state Conservation Land Tax Credit cap to help more privately-owned NWL to remain as NWL with a tax credit on the land donations; and increase the annual budget for other grant programs, including the Local Acquisition for Natural Diversity (LAND) and the Conservation Partnership.

[80] Mass Audubon's 6th edition of *Losing Ground: Nature's Value in a Changing Climate*, released in 2020, indicates the rate of land conservation is about 40 to 54.8 acres per day, which equates to 14,600-20,002 acres per year. This figure likely includes land protection beyond conservation efforts directly funded by state grants. This figure may also count only dry land protection, whereas EEA's ≥28% by 2025 and ≥30% land conservation goals include land and water. The *Losing Ground* report is available at https://www.massaudubon.org/our-conservation-work/policy-advocacy/shaping-climate-resilient-communities/publications-community-resources/losing-ground.

- EEA may potentially seek additional state funding to **expand the Agricultural Preservation Restriction (APR) Program beyond its current model** to protect farms that currently do not qualify for APR due to soils, acreage, land values, ownership, forest, and other criteria. Today, less than 75,000 acres of farmland have state-held Agricultural Preservation Restrictions.
- By the end of 2024, EEA will develop and seek to advance new legislation to support the goal of No Net Loss of Forest and Farmland. This will include amendments to the Chapter 61 and 61A current use program to allow parcels of 3 acres or more to qualify (current tax incentives are for conserving forest land of 10+ acres and farmland of 5+ acres). This will also include a state Payment in Lieu of Taxes (PILOT) bonus to facilitate land protection in rural communities with a low tax base and high percentages of state conservation land.
- EEA will also **partner with municipalities, land trusts, and other conservation organizations to encourage additional NWL conservation** above and beyond the state conservation goals for 2025 and 2030, including the pace of conservation restrictions.

Limit NWL Conversion

In addition to land acquisition and conservation, the Commonwealth will look to provide incentives and pursue the regulatory changes described below that aim to decrease NWL conversion to development.

- EEA will seek an increase in the Land Planning Grants annual budget that would provide expanded grant funding to municipalities and regional planning agencies to **enhance the adoption of Natural Resources Protection Zoning (NRPZ) and tree protection bylaws and incentives**. NRPZ and related "cluster development" techniques regulate new subdivisions of land in a manner that maximizes the protection of NWL. Tree protection bylaws and incentives can limit or mitigate tree removal during housing development.
- By the end of 2022, the MEPA Office will deliberate with the MEPA advisory committee, which was formed to advise on MEPA's 2021-2022 regulatory review effort, the potential to add a review threshold in regulation that would **require projects engaging in a certain level of forest clearing to undergo an environmental review process**. Additional refinements to the MEPA GHG Emissions Policy and Protocol will be considered to enhance analysis of forest lands, wetlands, and croplands/grasslands for projects that exceed existing review thresholds for land alterations.
- By the end of 2023, DOER will provide **guidance for future solar siting through the Technical Potential of Solar Study.** Such guidance is expected to help minimize environmental impacts and forgone carbon sequestration on NWL while meeting renewable energy needs for electrification of building heating and transportation. Chapter 6, Strategy E4, further discusses the Technical Potential Solar Study and the Commonwealth's commitment to deploy more solar projects on "built" landscapes.
- By the end of 2024, MassDEP will investigate approaches to increase statewide protection of wetlands and, at minimum, the first 50 feet of the 100-foot wetland buffer zone. The approaches (e.g., general permit with deed restriction requirement) must protect areas containing critical wildlife habitat or vernal pools. Under the Massachusetts Wetlands Protection Act (M.G.L. Chapter 131, §40), no one may remove, fill, dredge, or alter any wetland

zone without approval from the local conservation commission that protects the wetland "interests" identified in the Act. About 58% of municipalities in Massachusetts have wetland bylaws or ordinances that may provide additional protections to wetlands beyond the state law. However, only 17% of municipalities specify no build, no disturbance, or no alteration requirements for areas within the first 50 feet of the wetland buffer zone.[81]

STRATEGY L2: MANAGE NWL

A little over 200,000 acres of forests in Massachusetts—approximately 11% of all privately owned forest lands in the Commonwealth—are currently enrolled in the Chapter 61, 61A, and 61B tax programs, which allow privately owned forest lands to be taxed at the current use value of the property instead of the fair market or development value of the land. Enrollment in these programs requires that property owners keep their forests as forests for a minimum of 10 years and develop a forest management plan or a forest stewardship plan (which builds upon a forest management plan with a holistic assessment of the forest resources on the property). Written by professional foresters and reviewed and approved by DCR, forest stewardship and forest management plans could be developed to incorporate site-specific climate smart practices that factor in the site's forest age, tree composition, carbon stock and sequestration potential, prevalence of invasives and pests, and vulnerability to disturbance and increased risks from climate change.

Currently, the Commonwealth does not have reliable data on the extent to which healthy soils practices are being implemented on Massachusetts agricultural lands. The recently launched Massachusetts Coordinated Soil Health Program—a collaborative effort among the Massachusetts Department of Agricultural Resources (MDAR), American Farmland Trust, and University of Massachusetts, Amherst Extension—is providing educational resources and technical and financial assistance to farmers to implement healthy soils practices, such as no- or low-tillage and use of cover crops, that increase carbon storage in our agricultural soils. MDAR's Climate Smart Agriculture Program is funding the acquisition of equipment to help farmers transition to healthy soils practices.

Picture 22. Heifer International Garden. Photo credit: MA Office of Travel & Tourism flickr site

To achieve the goal of 20% of privately owned forests and farms adopting climate smart management practices by 2030, the Commonwealth will seek to provide financial incentives for forest landowners and farmers to implement management practices that increase carbon stock in their forests and farms while increasing the resilience of their land to ecological disturbances and climate change, including:

- By the end of 2023, DCR will seek to **launch a new Forest Resilience Program** as part of the agency's Working Forest Initiative, which already offers cost-share payments for forest

[81] Based on a database of municipal wetland bylaws/ordinances, last updated in 2019 by the Massachusetts Association of Conservation Commission.

landowners of at least 10 acres to complete forest stewardship plans as part of the Forest Stewardship Program. The goal of the Forest Resilience program is to provide financial incentives to private and municipal landowners of at least 10 acres to adopt verified forestry practices (such as thinning, extended rotation, tree retention, setting aside forest reserves, etc.) over 20 years or more to expand carbon storage and improve forest climate resilience.

- By the end of 2026, EEA will seek an amendment to the Massachusetts Forest Tax Law to modify the Chapter 61 and Chapter 61A programs or to **establish a new Chapter 61C program**, offering participating private and municipal landowners an additional incentive to accompany the longer-term commitment of keeping their forest lands in current use and practicing climate smart management. The Forest Resilience Program, when it is fully operational, could serve as the entrance requirement for the program. Farmlands could also be eligible for entrance to Chapter 61C if they can incorporate healthy soils practices in a measurable way.
- Beginning in 2024, MDAR will seek to provide additional financial incentives to farmers through the MA Coordinated Soil Health Program for implementing healthy soils practices that increase carbon storage in agricultural soils.

STRATEGY L3: RESTORE NWL

Increase Tree Coverage in Non-Forested Areas

Picture 23. Department of Conservation & Recreation Planting Trees with Children

Completing at least 16,100 acres of riparian and urban tree planting will require significant expansion and pace of current tree planting programs in Massachusetts. There are significant amounts of unforested open space in the Commonwealth that are within 100 feet of a river, stream, pond, lake, and other water bodies. Eight to nine hundred (800–900) miles of these riparian buffer areas, covering 10,700 acres, will need to be planted in the next eight years. An additional 5,400 acres of urban tree planting will take place on developed open space, prioritizing EJ communities that tend to have high areas of impervious surfaces and can greatly benefit from increased tree canopy to mitigate urban heat islands and stormwater flooding. As part of the Greening the Gateway Cities program, DCR has planted approximately 30,000 trees in EJ communities at a density of 5 trees per acre. Below are specific policies and actions EEA and its state agencies will implement to realize the tree planting goals for 2025 and 2030.

- By the end of 2023, DCR will seek to **launch a Riparian Tree Planting Program** to significantly expand tree cover along rivers, streams, lakes, and ponds, as well as retain edge/transitional habitat along farm fields. The Riparian Tree Planting program would work with local land trusts, conservation districts, and watershed associations to find appropriate locations in EJ communities, institutional lawns, developed areas, and low production farm fields that would have the best water filtration and habitat benefits. State funding for the program would

complement funding from the Conservation Reserve or Environmental Incentives Programs or other U.S. Department of Agriculture (USDA) landowner cost share programs.

- EEA will seek additional increases to the annual budget of the **Greening the Gateway Cities program** to accelerate urban tree plantings in EJ neighborhoods. The budget for the Greening the Gateway Cities program was recently increased with the first tranche of ARPA funding, resulting in an expanded annual budget of $8.3 million for Fiscal Years 2023 through 2025. With this funding, the program launched the Tree Planting Implementation Grant Program to provide Gateway Cities and qualified non-profit organizations financial support for urban tree planting and related activities at a larger scale. Additional increases to the annual budget would expand the Tree Planting Implementation Grant Program.
- Beginning in 2024, EEA will dedicate at least $3 million per year in the Municipal Vulnerability Preparedness (MVP) Program Action Grant funding for greening and nature-based projects to lower heat island impacts and increase urban carbon storage.

Improve and Expand Wetland Restoration

Achievement of no net loss of stored carbon in wetlands will require conserving not only the wetlands but also the land adjacent to and upstream of wetlands, as land management upstream and around the wetlands can significantly disturb and degrade the wetlands. It will also require more stringent standards for replicated inland wetlands, and proactive restoration of degraded wetlands and of coastal wetlands impacted by rising sea level. To that end, the following actions will support wetland protection:

- By the end of 2024, MassDEP will **implement a no net loss of stored carbon requirement** in the Bordering Vegetated Wetlands (BVW) General Performance Standards (310 CMR 10.55(4)(b)) and **a minimum of 2:1 replacement to loss ratio** to 310 CMR 10.05(10) to memorialize the longstanding requirement of projects seeking variance. The BVW replacement standards currently do not address protection of the rich carbon storage in wetland soils. With an added requirement of no net loss of stored carbon, replaced wetlands will need to have organic soils, which contain much higher densities of carbon than mineral soils. Additional carbon storage can also be achieved with the planting of wetland vegetation and trees in and around the replaced wetlands.
- By the end of 2024, MassDEP and the MEPA Office will investigate and identify ways to **streamline permitting and environmental impact review for wetland restoration projects** that restore tidal wetlands, remove tidal flow restrictions, and restore salt marsh functionality. Eligible projects would be target for an accelerated approval process.

STRATEGY L4: INCENTIVIZE LONG-LIVED, DURABLE WOOD PRODUCTS

Wood products are the primary local, NWL-derived product in Massachusetts in terms of carbon sequestration and emissions reduction. Using harvested wood in long-lived, durable products can help reduce emissions from forest-related activities, incentivize sustainable production of materials, and help retain forests as forests. While harvesting forests results in short term losses of forest carbon, careful

planning and management can ensure Massachusetts' working forests can continue to sequester carbon while also storing carbon in useful wood products over long periods of time.

Locally harvested wood can replace building materials that have a larger carbon footprint, like steel and concrete, thereby reducing carbon emissions. There are also new opportunities to use engineered wood products (e.g., cross-laminated timber) for construction of large wood-structure buildings approaching 20 stories in height. The total carbon cost of these new wood buildings can be substantially less than similar buildings built of steel and/or concrete.[82, 83]

Massachusetts is a net importer of wood, with only a very small fraction of wood products used in Massachusetts grown in the Commonwealth.[84, 85] Harvesting wood here—where growth far exceeds harvest levels—can help ensure harvesting is performed sustainably, in contrast to importing wood products from places with fewer environmental safeguards and more negative carbon impacts, including transportation-related emissions. In addition, local timber is important for supporting Massachusetts' local natural resource-based economies.

The fate of harvested or removed biomass is a key consideration in the carbon balance of any forest disturbance, including forest management. While cutting and removing trees results in an initial loss of carbon stocks from the landscape, a variety of processes determine the long-term carbon storage and emissions of any particular harvest. These include the proportion of harvested trees that is utilized, the growth and decomposition rates of unharvested biomass, the efficiency of harvested wood processing, and the longevity and decomposition rates of manufactured wood products. Using traditional harvested wood product accounting methods, wood harvesting results in approximately two parts of carbon emitted for every one part of carbon stored, accumulated through time at current rates of use and decomposition.[86] However, shifting the fate of harvested wood can reduce the total emissions associated with the carbon stock removal.

Utilizing harvested wood to produce additional or longer-lived durable goods and materials can maintain a larger portion of the removed carbon in storage for years (e.g., paper produced from pulp), to decades (e.g., furniture), to over a century (e.g., cross-laminated timber or insulation in buildings), reducing the net emissions associated with the removal activity. To the extent such products displace those with a higher embodied carbon footprint, additional reductions in GHG emissions are possible. Furthermore, as long as the harvested land continues in forest use post-harvest, the establishment of new trees and

[82] Chadwick Dearing Oliver, Nedal T. Nassar, Bruce R. Lippke & James B. McCarter (2014) Carbon, Fossil Fuel, and Biodiversity Mitigation With Wood and Forests, Journal of Sustainable Forestry, 33:3, 248-275, DOI: 10.1080/10549811.2013.839386

[83] Monetizing the Carbon Benefits of Mass Timber to Scale Up Its Deployment in Mid-Rise Housing and Commercial Development: A Pilot in the Metropolitan Boston Area, Olifant, LLC. USDA Forest Service Grant Number: 2019-DG-11420000-132. https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovations-data

[84] Berlik, M.M., Kittredge, D.B. and Foster, D.R., 2002. The illusion of preservation: a global environmental argument for the local production of natural resources. Journal of Biogeography, 29(10-11), pp.1557-1568. https://doi.org/10.1046/j.1365-2699.2002.00768.x

[85] Howard, James L.; Liang, Shaobo. 2019. U.S. timber production, trade, consumption, and price statistics. 1965-2017. Res. Pap. FPL-RP-701. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 96 p.

[86] EEA. 2020. Land Sector Technical Report, Massachusetts 2050 Decarbonization Roadmap Study. https://www.mass.gov/doc/land-sector-technical-report/download

growth of remaining trees on the land will temporarily increase sequestration of carbon on these lands, due to less resource competition. Therefore, both how we process and use the carbon in harvested wood products, as well as the silvicultural practices used to remove that wood, can affect the carbon storage and sequestration potential from our forest lands.

Until recently, there has been a lack of reliable data on the fate of wood harvested in Massachusetts, including the proportions processed into wood products of varying longevity and where these products are sold or used. EEA has commissioned an ongoing study to update its harvested wood accounting methodology to reflect the latest data on harvested wood carbon transfers in Massachusetts. Based on recent forest inventory data collected in Massachusetts,[87] an estimated 41% of the carbon contained in the biomass (above and belowground) of harvested trees in Massachusetts has the technical potential to be used in long-lived, durable wood products.[88] By 2025, EEA and its state agencies will assess the portion of harvested trees that are used in long-lived, durable wood products through expanded data collection on wood harvests and surveys of mill operators. From this baseline, EEA and its agencies will seek to improve the durable wood product recovery rate of harvested wood by 5% between 2025 and 2030. Much of the 5% improvement could be achieved through increasing wood processing efficiency, as observed by the National Sawmill Improvement Program previously administered by the USDA Forest Service.[89]

Picture 24. Research into Cross Laminated Timber Products Made from Eastern White Pine and Eastern Hemlock. Photo credit: Dr. Peggi Clouston, UMass-Amherst

An increase in the utilization of harvested wood in long-lived, durable wood products will require careful coordination with the forest management actions taken under the L2 Manage NWL strategy. In particular, implementation of the Forest Resilience Program could sustain supplies of sawlog quality trees into 2050 and beyond via thinning, pruning, and extended rotations of naturally regenerated forests, while avoiding the short-term depletion of large trees necessary for multiple ecosystem services. Lower quality trees removed as part of necessary thinning can also be used in long-lived, durable wood products.

[87] US Forest Service Forest Inventory and Analysis data, 2019 evaluation group year. See https://www.fia.fs.fed.us/library/database-documentation/ and https://www.nrs.fs.fed.us/fia/data-collection/.
[88] This represents the carbon in the merchantable bole wood (excluding rotten, missing, and form cull; and not including bark) of growing-stock trees, expressed as a proportion of total carbon in the above and below ground portion of all live trees, removed by harvesting. Growing-stock is briefly defined as all live trees of commercial species that meet minimum merchantability standards. Harvest removals are cut and utilized trees, or trees killed as a result of harvest operations but not utilized, defined here on forest land remaining forest land (i.e., not harvests as a result of change of land use to or from forest land). Current wood utilization practices may vary from FIA definitions of merchantability.
[89] Lunstrum, Stanley. 1982. "What have we learned from the sawmill improvement program after 9 years" Southern Lumberman. https://www.fpl.fs.fed.us/documnts/pdf1982/lunst82a.pdf

Below are specific policies and actions EEA and its state agencies will implement to increase the utilization of harvested timber in long-lived durable wood products and improve timber processing efficiency.

- Starting in 2023, DCR will pilot a program to collect information on where wood harvested on privately-owned and state-owned forests in the Commonwealth is processed. The pilot program may add reporting requirements to the forest cutting plans currently required by the Forest Cutting Practices Act, which applies to commercial timber cutting of wood volumes greater than 25 thousand board feet or 50 cords on any parcel of land at any one time. The pilot program will also gather information on wood processing of tree removals not captured by the forest cutting plans.
- Starting in 2023, DCR will commission a mill recovery study to assess common end uses of timber harvested in Massachusetts.
- Starting in 2023, DCR will commission a study to identify potential opportunities to support a local market for durable wood products in Massachusetts from sustainably harvested wood.
- By the end of 2024, DCR will seek to **expand the Forest Viability Program** to fund technical assistance and financial incentives for increasing efficiency in timber processing and expanding the market for low quality wood to be used as durable wood products. If fully funded, the program would include the following features: (a) direct financial assistance to businesses to support increased recovery of long-lived wood products from trees harvested in Massachusetts, workforce retention, advanced manufacturing practices, strategic electrification, and sawmill energy efficiency; (b) incentives for developers to purchase cross laminated timber (CLT) made regionally from eastern hemlock;[90, 91] (c) pilot incentive program to enable local housing authorities/trusts to use native lumber in construction projects; and (d) financial support for local durable wood product markets and workforce training.

STRATEGY L5: EXPLORE ADDITIONAL CARBON SEQUESTRATION

Achieving net zero in 2050 will require real, verified annual sequestration of as much as 14.2 $MMTCO_2e$ by resources in, or attributable to, the Commonwealth. EEA's current assessment is that NWL in Massachusetts are not likely to be capable of sequestering carbon dioxide at this rate in 2050 without seriously compromising other ecosystem services and land uses. Thus, it will be necessary to develop regionally consistent sequestration measurement, accounting, and market frameworks that will allow Massachusetts to purchase additional, least-cost sequestration services from other states in the region to allow the Commonwealth to achieve net zero GHG emissions in 2050. Since it is important to develop

[90] Kaboli H, Clouston P, Lawrence S. 2020. "Feasibility of Two Northeastern Species in three-layer ANSI Approved Cross Laminated Timber." ASCE Journal of Materials in Civil Engineering. 32(3), 04020006 https://ascelibrary.org/doi/full/10.1061/%28ASCE%29MT.1943-5533.0003058?mi=3i1ciu

[91] Hemlock Cross Laminated Timber Certification and Demonstration Project, North East State Foresters Association. USDA Forest Service Grant Number: 2021-DG-11094200-098 https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovations-data

and use a common carbon sequestration accounting framework,[92] the Commonwealth is participating in a multi-state effort with the support and facilitation of the U.S. Climate Alliance to develop this framework. Working closely with other states with mid-century net zero GHG emissions goals, this effort aims to:

- By 2025, develop an accounting framework for achieving net zero GHG emissions in state and with other jurisdictions outside of Massachusetts.
- By 2025, develop a framework design of the necessary elements (e.g., eligibility, registry, measurement, crediting, monitoring, and enforcement) of a viable carbon sequestration market.

[92] Although a carbon sequestration market may resemble, and perhaps be capable of interacting with, current and future carbon offset markets, it is anticipated that the carbon sequestration market would deliver a separate and distinct product that is not equivalent to technologically and economically feasible offsets of emissions.

CHAPTER 9: EMPLOYMENT, MACROECONOMIC IMPACT, AND EQUITY ANALYSIS OF THE 2025 AND 2030 DECARBONIZATION PLAN

The decarbonization policies and approaches contained in this 2025/2030 CECP will have substantial impacts on Massachusetts residents and the economy. To estimate these impacts, BW Research Partnership and Industrial Economics, Incorporated (the research team) worked with EEA to model the employment, macroeconomic, and equity impacts of the decarbonization pathway. This chapter examines employment gains and disruptions, economic contribution to Gross State Product (GSP), and impacts on household energy expenditures as the Commonwealth implements the policies to meet its decarbonization goals. This chapter includes suggestions from the research team to maximize the employment, economic, and other benefits of this 2025/2030 CECP.

9.1 RESEARCH METHODOLOGY OVERVIEW

The analytical methodology was developed through a combination of an extensive literature review, the economic impact modeling experience of the research team, and the direction of EEA. This research focused on measuring the change in employment and economic activity in seven primary sectors of Massachusetts' economy: Electricity, Fuels, Buildings, Transportation, Natural and Working Lands, Industrial Energy Efficiency, and Municipal Solid Waste. These sectors are defined more specifically in Appendix D. These sectors are similar to the sectors used in the other chapters of the CECP, but some of these sectors do not directly overlap. Industrial Energy Efficiency and Municipal Solid Waste, which are listed separately in this chapter, are clustered together as a Non-Energy Sources & Industrial Use sector throughout the rest of the CECP. Each of the seven primary sectors was further delineated into a total of 32 sub-sectors. For example, the Fuels sector includes the sub-sectors of Hydrogen Fuels, Biofuels, Natural Gas Fuels, and Petroleum Fuels.

The Initial Employment Outputs (IEOs) are analytical estimates of the changes in the number of jobs from 2019[93] to 2025 and 2030. The research team also modeled employment impacts through 2050; however, this chapter primarily focuses on employment impacts up to 2030 with periodic reference to significant impacts through 2050. The IEO estimates were generated from input-output models, including Impact Analysis for Planning (IMPLAN) and Jobs and Economic Development Impact (JEDI), which were used to translate activities and investments for each sub-sector into an estimate of employment over time.

The Secondary Employment Outputs (SEOs) are estimates of how employment will change by occupation, wage, and geographic distribution across Massachusetts between 2019 and 2030. The estimates for the SEOs were generated from the direct and indirect employment estimates when conducting the IEO analyses and combined with industry staffing patterns, occupational crosswalks, and employment profiles by value chain to provide more granular analyses. The research team also used

[93] 2019 was used as the baseline year for this report rather than 2020 to avoid pandemic-related volatility in employment data.

granular energy use and demographic data to estimate the likely economic effects on Massachusetts households' energy budgets.

The analysis contained in this chapter compares the workforce changes spurred by decarbonization activities to the Massachusetts workforce today.[94] For a more detailed description of the research methodology used for this report, please refer to Appendix D of this Plan.

9.2 EMPLOYMENT AND ECONOMIC IMPACTS OF DECARBONIZATION

INITIAL EMPLOYMENT OUTPUTS

IEOs provide an estimate of the total change in the number of jobs from the seven sectors and their 32 sub-sectors from 2019 to 2025 and 2030. IEOs include induced employment, which is economy-wide jobs that are created through energy-related economic activity. For example, a local diner may hire a new waitstaff to support the increased demand from the nearby offshore wind export cable facility. The key findings from the research are provided below.

From 2019 to 2030, the number of jobs likely to be added from growing sub-sectors is more than four times greater than the number of jobs lost in displaced sub-sectors. This means that more than four jobs will be created and sustained for every worker displaced. The results of the IEOs show that total employment in the 26 growing sub-sectors will increase by more than 12% from 2019 to 2030, adding and supporting 29,500 new jobs in the Commonwealth. During this same time, the six sub-sectors with displaced workers are projected to experience a decline in employment of about 17% from 2019 to 2030, shedding approximately 6,900 jobs.

A net 22,600 additional full-time jobs will be created and supported through 2030 from the 2019 level of employment, representing an 8% increase. This addition of jobs is roughly equivalent to the number of employees in the Insurance Agencies and Brokerages in Massachusetts. In comparison, the Massachusetts Department of Unemployment Assistance projects that the overall Massachusetts economy will add 112,700 jobs between 2018 and 2028, meaning that the decarbonization policy outlined in this report could boost employment growth by roughly 20% beyond what is projected. By 2050, an additional 66,000 jobs beyond 2019 employment levels are estimated to be created, which is equivalent to the number of workers currently employed in Offices of Physicians[95] around the state.

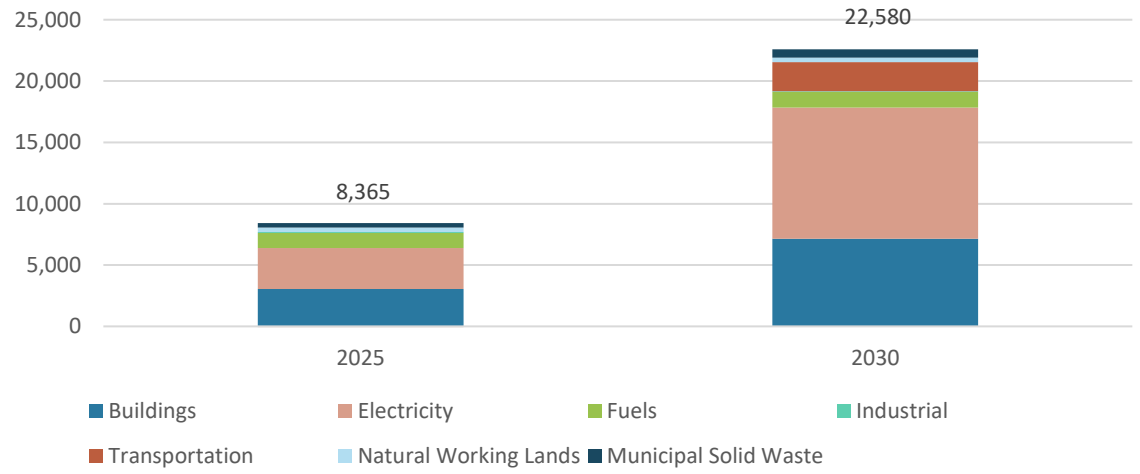
By 2030, these seven sectors will account for $29.5 billion in Gross State Product.[96] For context, this represents more economic activity in the state than Offices of Real Estate Agents and Brokers and Full-Service Restaurants *combined.*

The Electricity[97] and Buildings sectors are projected to see the greatest increase in employment, respectively adding 10,700 and 7,100 jobs by 2030. The rapid electrification of the economy means

[94] This means that, while many of these impacts are driven by policy, some—such as an increase in the market demand of biofuels—are not.
[95] Excluding Mental Health Specialists.
[96] Dollar values are in 2019 dollars and do not account for inflation.
[97] The Electricity sector does not include employment from decommissioning activities at the Pilgrim Nuclear Power Station.

that the Electricity sector will grow by 14%, which is significant given the number of workers already in the sector. Buildings employment increases by a more moderate 6%. While this 2025/2030 CECP does not include any fuel blending requirements, greater market demand for biofuels means that the relatively small Fuels sector will also see a high rate of growth (14%) between 2019 and 2030. The other large and more established sector of Buildings and Transportation will see some growth, growing 6% and 3% respectively. The smaller sectors of Municipal Solid Waste, Industrial Energy Efficiency, and Natural and Working Lands will each add 100 or more jobs between 2019 and 2030, though these employment impacts are small relative to the changes experienced in other, larger, industries (Figure 9.1).

Figure 9.1. Net Jobs Created by Sector from 2019 Baseline



The sub-sectors of EV Chargers (+5,900), Solar PV (+4,000), Residential Buildings Envelop (+3,700), Transmission[98] (+2,900), Offshore Wind (+2,800) are the greatest sources of additional jobs. These sectors account for a majority of the projected employment growth by 2030. Growth in these sub-sectors means there will be high demand for workers who can install charging stations for EVs; mount and connect solar panels; install insulation in walls, attics and crawl spaces; lay additional transmission wires for a larger and smarter electrical grid; and install offshore wind turbines. To provide a sense of scale, the employment growth of each of these sub-sectors is roughly equivalent to—or greater than—the number of people employed in breweries around the state. Combined, the job additions in these five sub-sectors equate to the current number of Preschool and Kindergarten teachers in the state.

Net employment in the Transportation sector will see modest growth overall, though sub-sectors within Transportation will see substantial changes. Employment in Fueling Stations is estimated to decline, as EVs decrease the demand for gas stations and their employees, unless the current gas stations remain to serve as electric charging stations or hydrogen fueling stations.[99] This loss of

[98] Transmission and Distribution are separated into distinct sub-sectors because they use separate inputs in both the energy and workforce models used to generate these estimates.

[99] The transition to EVs makes the future of gas stations and their accompanying retail employment unknown. For this study, the research team projected that home charging stations and fast-chargers will make fueling station retail stores largely obsolete. However, it is possible that future technology makes rapid electrical charging roughly time equivalent to filling up a gas tank, and therefore fueling station employment will remain largely unchanged.

employment is offset by a larger increase in workers (+5,900) involved in the installation and maintenance of EV chargers. Within the Fuels sector, fossil fuels-related employment remains relatively flat through 2030, while there is growth in Biofuels, which adds 1,800 jobs by 2030. These Biofuels jobs are driven largely by growing market demand rather than explicit policies; the EIA projects that U.S. biofuel production will grow 18%–55% between 2019 and 2050.[100] Employment in Hydrogen is forecasted to see a slow increase (+300) by 2030 but is anticipated to enter a phase of rapid employment growth between 2040 and 2050 as the technology matures further.

To support workers displaced or transitioned by decarbonization policies, Massachusetts may consider a variation of the federal Trade Adjustment Assistance (TAA) program. The TAA program provides funding and support to workers who are adversely affected by changes in international trade so that displaced workers can obtain new skills, credentials, and resources that help them secure new employment. A redesign of the TAA program for decarbonization could help displaced fossil fuel workers retrain and reskill to fill new jobs installing charging stations, installing offshore wind turbines, or retrofitting homes to be more energy efficient.

Construction industry jobs account for a majority (59%) of the net jobs created, including induced employment.[101] By 2030, an additional 13,200 construction industry jobs will be created and supported, representing a 7% increase in construction industry jobs from the current 196,400 construction industry workers economy-wide. For historical context, it took the Massachusetts construction industry three years of strong growth between 2017 and 2019 to add the equivalent number of jobs. The creation of many new construction industry jobs is notable because a 2019 survey[102] of energy efficiency employers found that 45% reported it was "very difficult" to hire for energy efficiency roles (which will make up many of these construction jobs) and another 48% reported it was "somewhat difficult." Only 8% of employers stated that it was "not at all difficult" to find qualified energy efficiency workers in the state. Notably, the unemployment rate in late Spring of 2022 is similar to the unemployment rate when the survey was conducted in 2019, meaning employers are likely having at least the same level of difficulty hiring right now. Increased demand for these workers will only exacerbate these hiring challenges.

One opportunity for easing talent challenges is to leverage the strength of construction unions in Massachusetts; 21.6% of construction workers in Massachusetts in 2021 were covered under union contracts.[103] Unions have strong workforce training attraction and development systems that could help prepare and train workers for these construction roles.

Thirty-two percent of the jobs created (7,200) will be economywide through induced employment. This means that for roughly every two energy-related jobs created, a non-energy, economywide job will be created via the spending effects of the policies. For example, those who are paid to construct new offshore wind projects will increase their spending at restaurants, electronics stores, and other places

[100] "EIA projects US biofuel production to slowly increase through 2050." March 9, 2020. https://www.eia.gov/todayinenergy/detail.php?id=43096

[101] Induced employment is employment that is created as energy workers, with new incomes from their labor, then spend their money throughout the overall economy on goods and services such as restaurants, healthcare, and automotives.

[102] "Massachusetts Energy Efficiency Workforce Development Needs Assessment" 2020. BW Research Partnership.

[103] Union Membership and Coverage Database from the CPS (Unionstats.com). Aggregated and maintained by Barry Hirsch of Georgia State University and David Macpherson of Trinity University.

throughout the economy, driving demand for new workers in these industries. Such effects further broaden the pool of current and potential workers that will benefit from additional employment opportunities.

A historically tight labor market in Massachusetts means that finding workers to fill these new jobs may require planning and coordination of workforce and economic development agencies across the state. As of January 2022, there were 180,000 people unemployed across the state, roughly 74,000 more unemployed individuals compared to January 2019 when the unemployment rate in the state was 2.8%. This notable number of presently unemployed workers suggests that some of these individuals may be able to fill a significant portion of these new jobs if they are willing and able to attain relevant training and are able to address other challenges, such as child-care and transportation. There also may be additional opportunity for drawing previously disengaged people into the labor force. For instance, while the February 2022 statewide labor force participation rate[104] was equivalent to the pre-pandemic rate in February 2020, it is 1.2 percentage-points lower than the peak labor force participation rate in February 2019 (67.1%).

Outreach and engagement of those who are unemployed or those currently outside of the labor market may be challenging. Close coordination with community-based organizations that are engaged with unemployed, underemployed, or discouraged workers could boost the effectiveness of outreach efforts. Working with community-based organizations that support minority, women, and other disenfranchised populations would also assist in ensuring the clean energy workforce is representative of the population at large. Training a large pool of potential workers that may not have recent or relevant work experience will add strain to the workforce development system. In 2019, the entirety of Workforce Training Fund Programs[105] trained 16,100 workers across the Commonwealth, which suggests that if training for new clean energy workers is spread out over the next seven years, the existing training systems may be able to meet this challenge, but the more likely and most desirable approach is to ramp up training immediately, which will require additional support and coordination to expand capacity.

SECONDARY EMPLOYMENT OUTPUTS

SEOs provide an estimate of how jobs are expected to change from 2019 to 2030 by occupation, wages, and geography across Massachusetts. SEOs include direct and indirect energy-related employment only, and therefore do not include induced employment. SEOs also do not include employment from Natural

[104] Labor force participation rate is the percentage of non-institutionalized people 16 and older who are actively working or looking for work. This metric shows what portion of the working age population is interested in working. If a population is proportionately older (more retirees) or more in school, (more 16-24 year olds in school), the labor force participation rate would be lower. Unemployment, on the other hand, is the number of unemployed in the numerator and labor force (employed and unemployed) in the denominator. Thus, it measures "of those who are looking for work, how many are unable to find work." Over the course of the COVID-19 pandemic, unemployment increased (many out of work) and labor force participation fell (fewer people interested in working overall). As of June 2022, both metrics are closer to pre-pandemic levels, and unemployment is reaching the point where Massachusetts is close to the "natural" or frictional rate of unemployment (people are always changing jobs so there will always be some unemployed). With very low number of people unemployed, the next place to look for new workers is at the labor force participation rate, and thinking about how one would help reach more people who were previously not interested in working.

[105] Workforce Training Fund Programs are operated by Commonwealth Corporation and provide Massachusetts businesses with resources to invest in the skills of their workforce. Financed by Massachusetts employers, WTFP offers matching grants up to $250,000 to offset costs of training workers.

and Working Lands, Industrial Energy Efficiency, or Municipal Solid Waste because their relatively small number of workers do not allow the research team to confidently estimate the composition of their workforce. This means that the total employment numbers will differ between IEOs and SEOs. Some important findings from the SEO are presented below.

Installation, Maintenance, and Repair occupations make up 79% of all net new energy-related jobs, which exclude induced employment.[106] The additional 11,500 Installation, Maintenance, and Repair jobs created by 2030 equate to a 10% increase of the 111,600 Installation, Maintenance, and Repair jobs within the state in 2021Q3. In the absence of these decarbonization activities, Installation, Maintenance, and Repair Occupations are projected to add only 3,200 jobs between 2018 and 2028.[107]

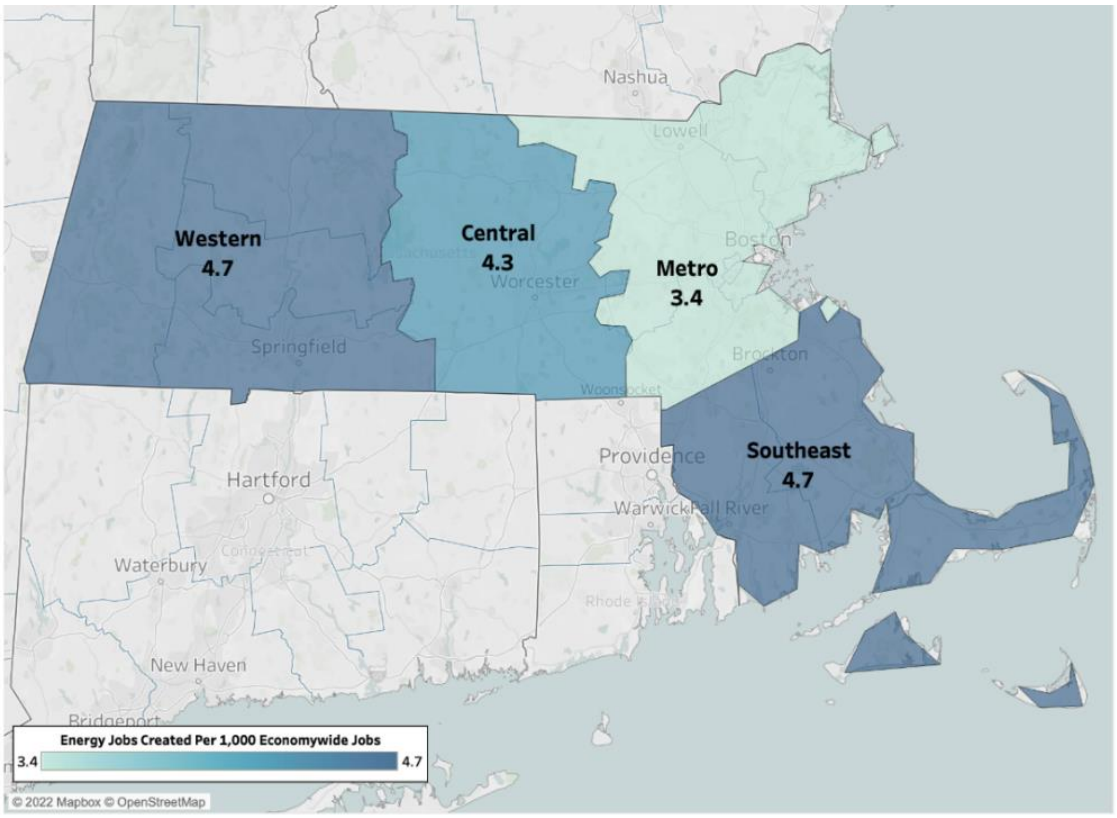
While these types of jobs are largely representative of the Massachusetts workforce by race and ethnicity, about 96% of Installation, Maintenance, and Repair occupations are currently held by men. This means that, unless deliberate policy actions are taken, a majority of the energy-related jobs created through these decarbonization policies would likely be filled by men. One potential strategy could be to require all public contracts to contain enforceable workforce participation goals for women. Another, and perhaps additional strategy, may be to work with community-based women's organizations to increase women's awareness, interest, and participation in Installation, Maintenance, and Repair roles and the training programs required to secure those roles.

Other occupations estimated to see substantial growth are Management and Professional roles, which account for another 20% of new energy-related jobs created. These roles are typically higher-paying and often require 4-year degrees. Energy-related administrative roles are projected to see overall declines of 10%, largely driven by the projected employment losses among fueling station jobs. Policies that support transition opportunities, such as the aforementioned TAA program, will be important to consider for these workers.

Energy-related jobs will be created across the state, and Western and Southeastern Massachusetts will see roughly 4.7 jobs created for every 1,000 existing economy-wide jobs. Although the Metro Area will see a relatively smaller proportion of jobs created (roughly three and a half jobs for every 1,000 current economy-wide jobs), it will see the largest overall number of energy-related jobs (+8,400) created by 2030 (Figure 9.2).

[106] Installation, Maintenance, and Repair roles are occupational classifications. Many of these jobs will be in the Construction industry, but some jobs may be outside of the Construction industry.
[107] Massachusetts Department of Unemployment Assistance.

Figure 9.2. Energy Jobs Created Per 1,000 Existing Economy-Wide Jobs.



Ninety-five percent of the net additional energy-related jobs created and supported by 2030 will be middle to high-wage jobs that earn at least $26 per hour. Half (52%) of all additional energy-related jobs earn $26–$35 per hour, and another 43% of additional energy jobs will make more than $35 per hour. This represents a significant opportunity for the Massachusetts economy. Similar to trends observed nationwide, an increasing share of Massachusetts workers are at the lower- or upper-ends of the income spectrum, while "middle-income" jobs have become more scarce. The energy-related jobs created through the decarbonization activities highlighted in this report would help mitigate some of this trend, by creating a large number of jobs with wages that are at or above the statewide median wage of $28.14 per hour. Importantly, following the figures developed by MIT's Living Wage Calculator project, a majority of these jobs are well above the living wage[108] in the state and many are at or above a family-sustaining[109] wage. Promoting and advertising high-demand clean energy occupations, their educational requirements, and wages, may be one way to draw future generations into decarbonization-related jobs. Campaigns that demonstrate educational pathways and earnings potential to students in middle and high school—as well as through traditional channels at workforce development boards and community colleges—may be successful in drawing in potential workers who are not currently in the labor market but may be interested in employment opportunities.

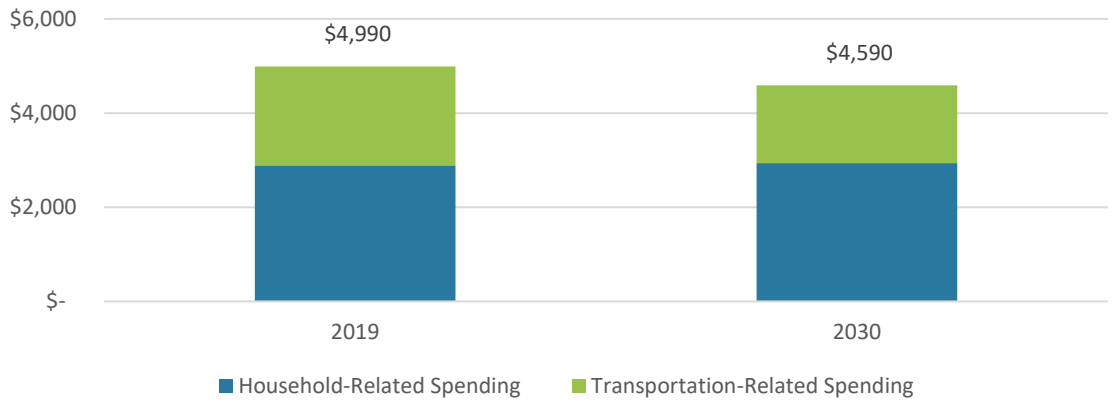
[108] The living wage for a single adult with no children in MA is $19.91.
[109] The living wage for a family of three (one child and one adult working) is $34.69 per hour.

HOUSEHOLD ENERGY EXPENDITURE IMPACTS

The research team modeled the anticipated impacts on household energy expenditures, including electricity, natural gas, other heating fuels, and gasoline. The key findings from this research are summarized below.

The increased adoption of electrified transportation and heating systems mean that the average Massachusetts household will spend less money on energy every year. Average overall household energy expenditures, which include transportation-related fuel costs (included as "energy" cost in this analysis), are projected to decline 8% by 2030 relative to 2019 levels, for an average household savings of $400 per year.[110] These values are an average of all households; a household with greater adoption of efficiency and electric technologies will see greater savings than those highlighted below, while a household that implements little or no changes will see little or no financial benefits. Decreases in Transportation-related expenditures are the primary driver of energy expenditure savings, while other household-related energy expenditures remain relatively flat between 2019 and 2030 (Figure 9.3).

Figure 9.3. Change In Household and Transportation-Related Fuel and Energy Costs Per Year (2019-2030)



Note: The costs are from simulated supply and demand balance in the energy resources. They do not include any assigned social costs of GHG emissions.

Historically disenfranchised populations are projected to see equal or greater household savings than the overall population, though additional policy safeguards can help guarantee that these communities are not disadvantaged by decarbonization policies. Households in EJ designated census block groups are estimated to see greater savings (decreases in expenditures of -11%) than households in non-EJ communities (-6%). Changes in the proportion of household income spent on energy fluctuate little across different household income levels, though we recognize that lower income households are less likely to be able to afford the initial expenditures required to electrify and generate savings down the road. To further ensure that lower-income households—which spend a greater share of their household income on energy—are not disproportionately impacted, Massachusetts could consider expanding policies that charge higher rates for the highest energy used. Another potential option could

[110] These values are in 2019 real dollars and do not account for inflation.

be the creation of an electrification tax credit that is available to households below a certain income threshold.

OTHER SOCIAL, ECONOMIC, AND ENVIRONMENTAL BENEFITS

In addition to the impacts related to employment, Massachusetts' decarbonization policies will result in other social, economic, and environmental benefits. These benefits are summarized below.

Air quality improvements will result in improved health outcomes valued at between $421 million and $949 million per year by 2030 (see Appendix D for more information). Based on EPA's model of county-level changes in ambient $PM_{2.5}$ resulting from emissions reductions, Massachusetts' decarbonization pathways are expected to result in 37 to 83 fewer premature deaths per year (the largest contributor to the economic value of these health benefits), 4 to 39 avoided cases per year of acute myocardial infarction, 45 fewer hospital and emergency room admissions per year, 4,600 fewer lost days of work per year, and 27,000 fewer days of minor restricted activity by 2030, among other benefits.

Decarbonization activities in each sector present unique benefits that will cumulatively have strong benefits throughout Massachusetts, such as the following:

- Alongside the economic and health benefits of lower GHG and other pollutant emissions, switching to renewable fuels and sources of electricity generation can increase energy security and potentially reduce energy cost volatility.
- Buildings that are more energy efficient have the added benefits of reducing owner energy costs overtime, offer re-sale values, reduce the risk of fire, and provide warmer and more consistent temperatures.
- In the Transportation sector, increased "active transport" (e.g., walking and bicycling) will lead to improved individual health, increased transit safety, and increased sales and property values at local businesses.
- New investments in natural and working lands will positively influence many environmental and social factors, including air quality, urban heat islands and related energy costs, erosion control, water quality, aesthetics, and recreational opportunities.
- Benefits from investments in Industrial energy efficiency may include reduced power costs to industry, reduced noise levels, and reduced maintenance costs.