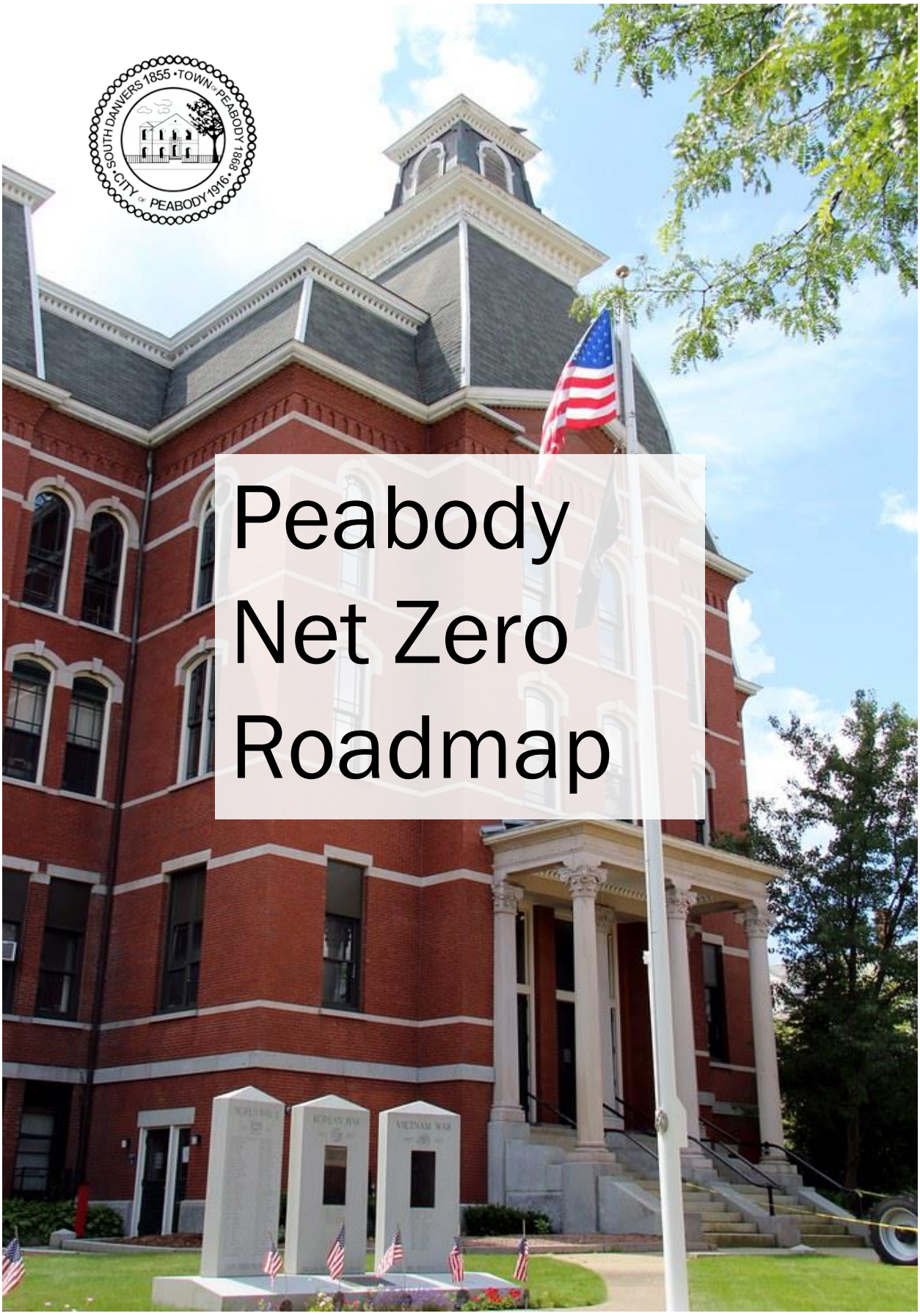


Peabody Net Zero Roadmap

Contents

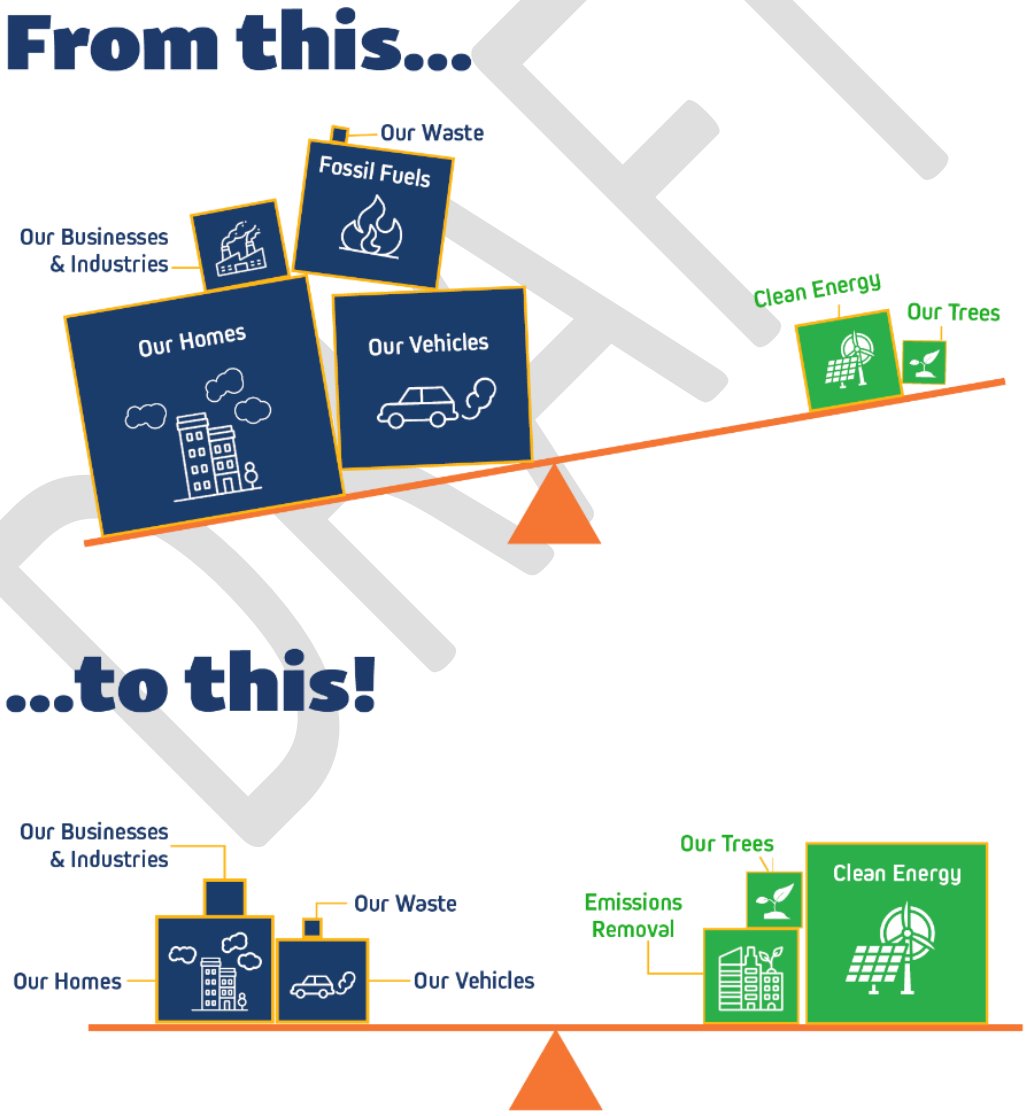
The Peabody Net Zero Roadmap was prepared by the Metropolitan Area Planning Council for the City of Peabody with support from a Planning Assistance Grant from the Massachusetts Executive Office of Energy and Environmental Affairs.

Getting to Net Zero

The City of Peabody is committed to reaching net zero greenhouse gas (GHG) emissions by 2050. What exactly does this mean for our community and why does this matter? What do we need to do to reach this goal? The Peabody Net Zero Roadmap answers these questions and charts our course to reach net zero by 2050.

What does "net zero" mean?

Reaching "net zero" means that our community will reduce its GHG emissions as much as possible and remove or offset any remaining emissions by 2050, ideally sooner. This will require a major shift in the way we heat and cool our homes, how we get around, and where our energy comes from. It also presents a huge opportunity to change our community for the better. By achieving net zero GHG emissions, we can also have cleaner air, healthier people, and a more equitable and prosperous community for everyone.



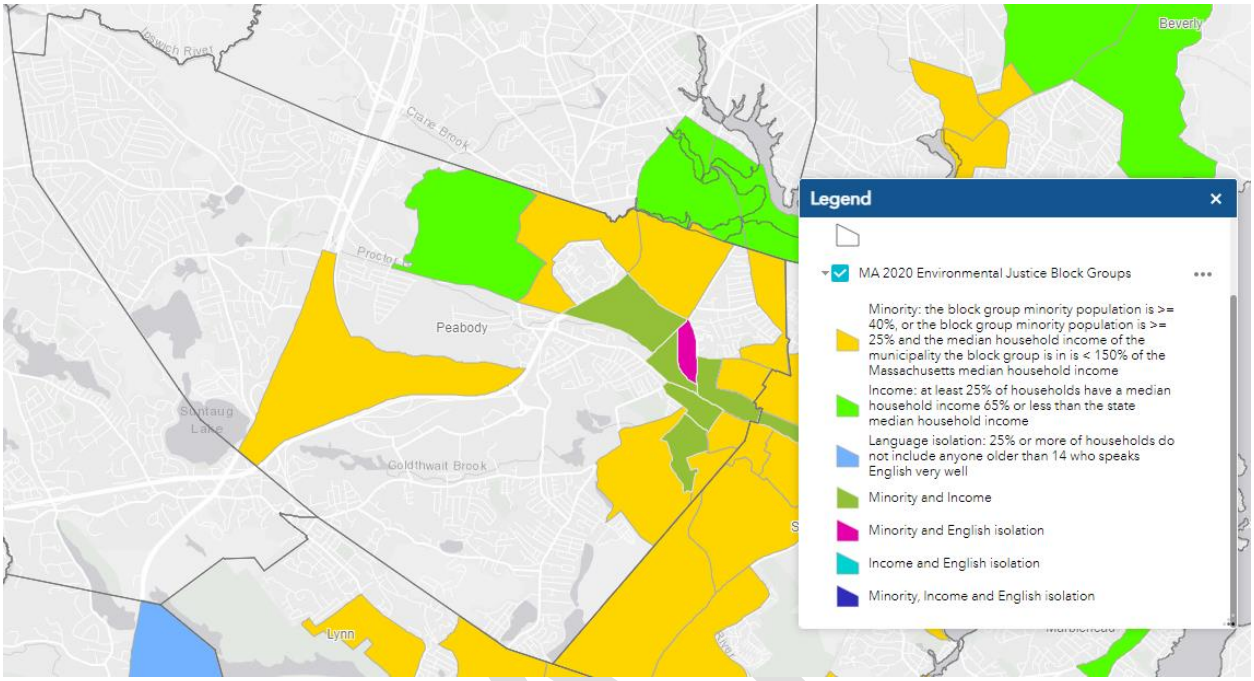
Why net zero?

Climate scientists have made it clear that we need to reduce global GHG emissions to net zero by 2050, or sooner, to avoid catastrophic climate change. We know that the planet has already warmed by about 1° Celsius since we started burning fossil fuels like coal, oil, and gas in the mid-1800s. We also know that if we can keep warming below 1.5° Celsius, we can avoid the worst impacts of climate change like extreme floods, wildfires, and droughts. We have a limited "carbon budget," or amount of GHG pollution that we can afford to put into the air without passing 1.5° Celsius of warming. The longer we wait to start reducing our GHG pollution, the faster we use up our carbon budget and the less time we give ourselves to meet our goal.

We recognize climate change is a global problem and that many of the solutions are beyond our control. To reach our net zero goal, we will need help from global, federal, state, and regional policies that support our transition to clean energy, but we can lead at the local level. During the spring of 2021, the Commonwealth enacted Senate Bill 9, An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy, which set the interim GHG reduction targets of no less than 50% by 2030 and 75% by 2040. Our net zero roadmap highlights the strategies that we can deploy locally to accelerate this transition over the next several years.

Getting there equitably

Climate change is an existential challenge, but it is also an opportunity to reimagine Peabody's future and to make that future safe, affordable, and equitable for all who live and work in our community. Massachusetts municipalities are increasingly undertaking climate mitigation and adaptation strategies and are starting to seek out ways to advance equity through those measures. By centering equity in this plan, we can build a future that not only is safer and affordable for all, but also allows each individual in Peabody to thrive. An equitable net zero carbon future must be our goal. In equitable planning, we must be conscientious of the history of our region, the differences in how populations are able to respond to a changing climate, and the needs of residents. We recognize that the effects of climate change systemically impact environmental justice (EJ) communities and other vulnerable populations inequitably. The comparatively negative health outcomes that people of color experience are one example. The inequities we see today will persist in the future if we do not act.



Peabody has 15 environmental justice block groups, shown in the map above generated using the Massachusetts 2020 Environmental Justice Populations mapping tool available here.

Many of the actions and strategies outlined in this roadmap include "equity considerations," observations about the ways in which the action can be and should be implemented to advance equity in our community and/or the inequities that the action can help redress.

Where we're starting: Peabody's GHG Inventory

To get a sense of Peabody's emissions baseline, the Metropolitan Area Planning Council (MAPC) completed an inventory of community-wide greenhouse gas emissions using its Community Greenhouse Gas Inventory Tool.[1] This inventory calculates emissions from buildings, transportation, waste, and other sources in Peabody for the calendar year 2017, the most recent year for which complete datasets are available. The inventory does not include emissions from boating or airplane travel. For a full description of the inventory methodology, see Appendix B.

Total emissions in Peabody for 2017 = 449,787 MT CO2e

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

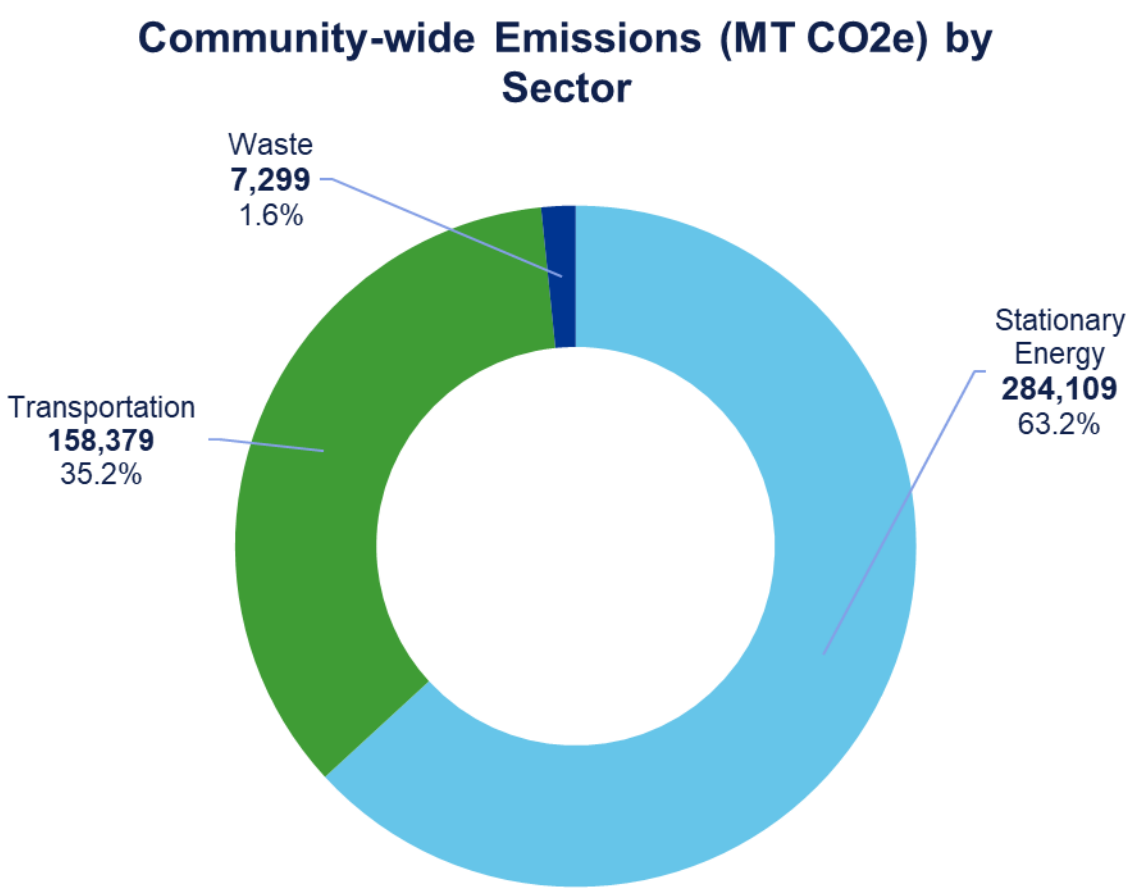
Peabody's GHG emissions in 2017 are as follows:

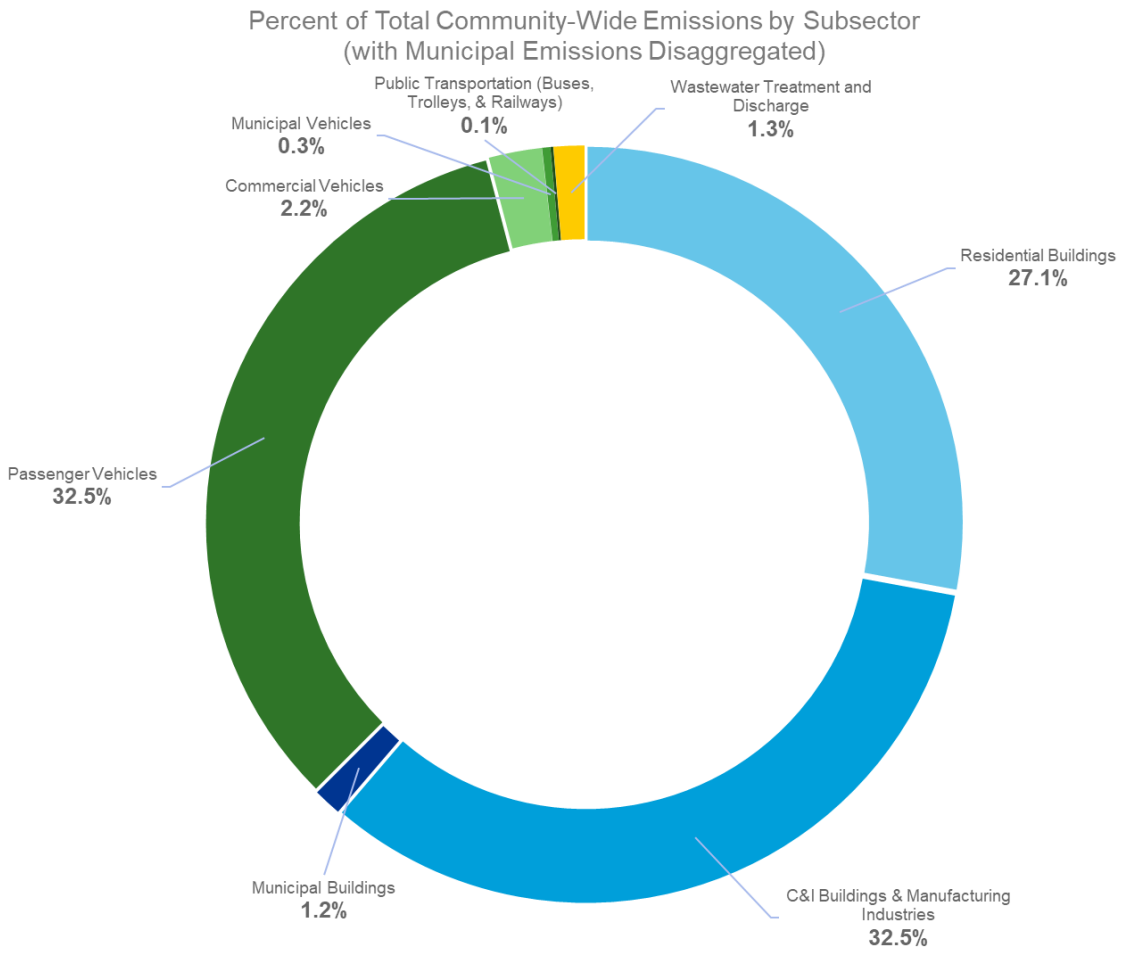
- 63.2% of emissions (or 284,109 MT CO2e) from the stationary energy sector (buildings and industry).
- 35.2% of emissions (or 158,379 MT CO2e) from the transportation sector.
- 1.6% of emissions (or 5,796 MT CO2e) from the waste sector.

8.4

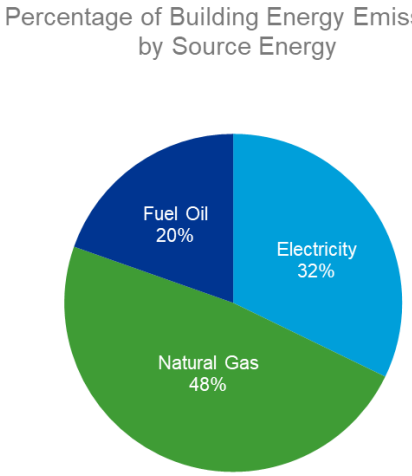
Metric Tons of CO2e per resident

Note: The emissions per person estimate is an approximation calculated by dividing Peabody's total emissions (including commercial emissions) by its population in 2017 (53,278).





From the stationary energy sector, the largest source of GHG emissions is Commercial and Industrial (C&I) Buildings and Manufacturing Industries, which are responsible for emitting approximately 34% of the total community-wide emissions. About 48% of building emissions come from natural gas.



It is also important to mention that although the stationary sector had the largest combined total emissions, on-road transportation has the single largest carbon emissions at approximately 35%. The largest source of emissions from passenger vehicles is gasoline, making up 98% of the total. This shows how critical it is for residents and businesses to work with the City to reduce their emissions.

How do we get there?

A lot can change in 27 years, and this plan is a starting point on our path to net zero that we will revisit and adjust as we continue to move forward in the coming years.

Currently, our GHG inventory summary shows that our community needs to focus on the sectors where the majority of our emissions are coming from – transportation and buildings, residential buildings specifically. Along with these two sectors, we will also be focusing on other efforts. To reach our net zero goal, our community will need to work towards six core transitions.

1. **Make our homes and buildings super-efficient.**

Making existing buildings superefficient and constructing new buildings to high efficiency standards will reduce emissions and make energy bills more affordable for everyone.

2. **Electrify heating and cooking equipment.**

Switching to electric heating and cooking appliances, like air-source heat pumps and induction cooktops, immediately reduces carbon emissions and improves indoor air quality, and these benefits only get better as our electric grid gets cleaner.

3. **Electrify cars, trucks, buses, trains, and other ways we get around.**

Electric vehicles are cleaner, cheaper to run over time, and require less maintenance. Providing access to charging stations and creating electric transportation options for those who do not own vehicles are essential to this transition.

4. **Make walking, biking, and public transit the best way to get around.**

By designing greener and people centered streets and sidewalks, we can reduce emissions and air pollution while also providing opportunities for residents to be healthier and more connected to their community.

5. **Green the grid with renewable energy sources.**

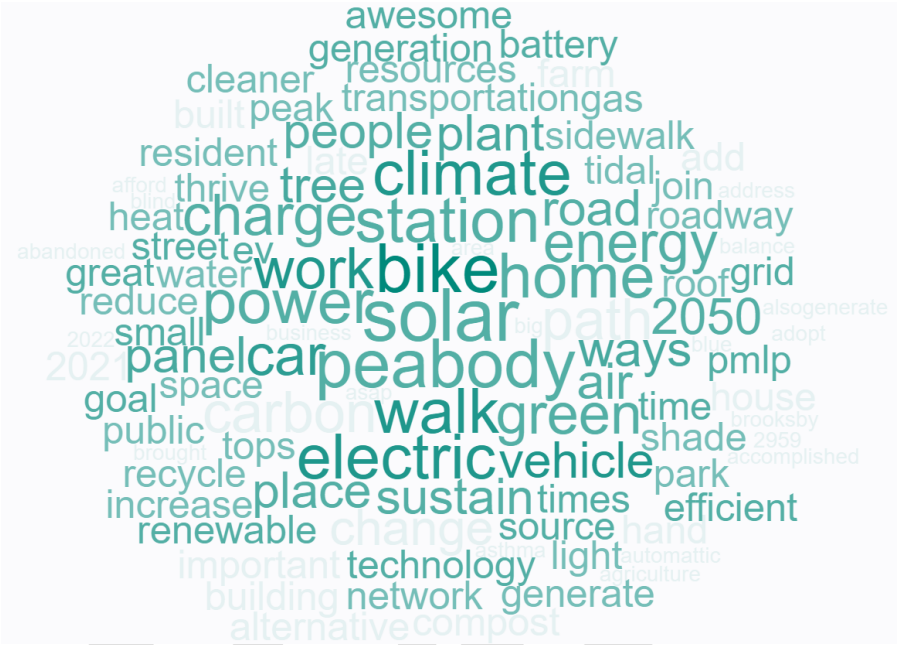
Renewable energy comes from endlessly sustainable sources such as wind, the sun's heat or light, and the earth beneath our feet. Our electricity is getting greener all the time thanks to state and local policies, but natural gas still powers most electricity in New England.

6. **Produce more renewable energy locally.**

Generating renewable energy locally avoids the expensive and inefficient long-distance transmission of power, and small-scale clean energy projects, such as rooftop solar PV, can provide new power sources more quickly than large developments.

What have we heard from the community?

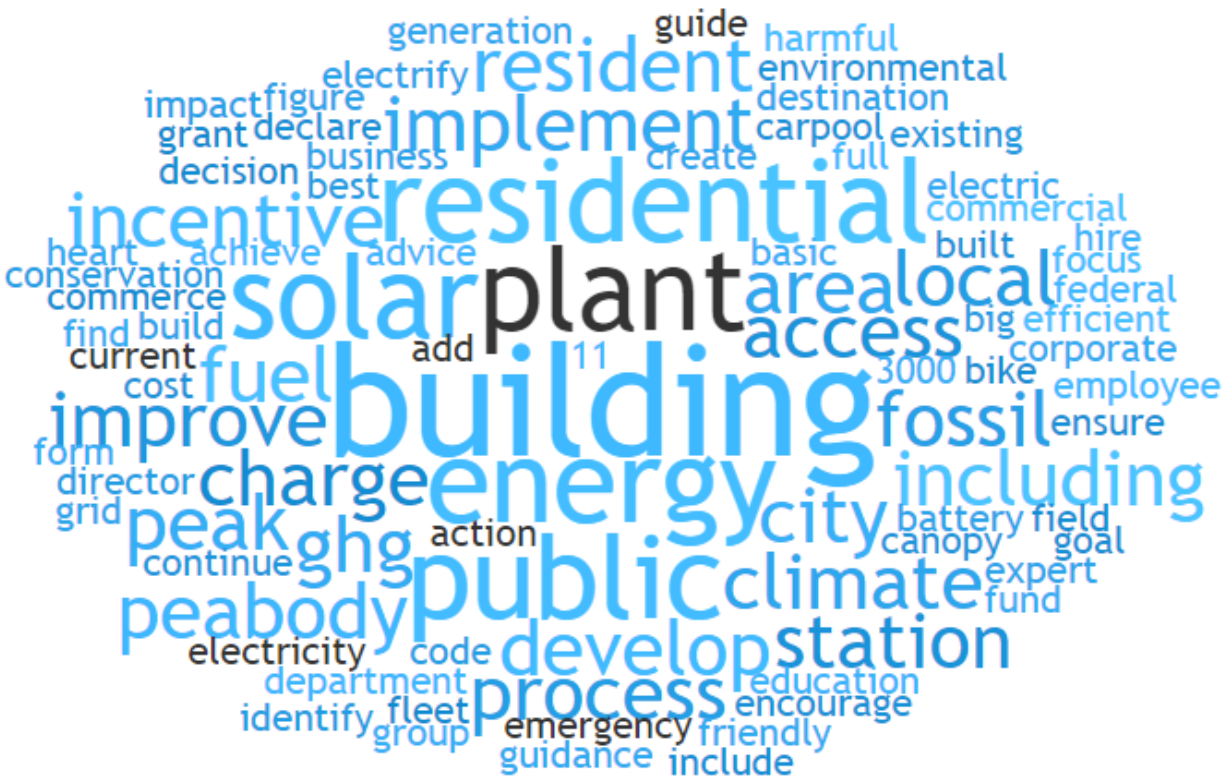
This roadmap was created with input from the Peabody community. In December 2021, MAPC and the City of Peabody hosted a virtual public workshop to gather input from the community to inform the roadmap. Participants were asked to envision the future in 2050 once Peabody has reached net zero emissions and share their thoughts about the most important climate actions that Peabody should take to reduce its emissions.



This word cloud displays the themes from workshop participants' visions of the future in 2050 once Peabody has achieved its climate goals.

An example of one of the virtual whiteboards from the Peabody Net Zero Workshop.

Following the workshop, the City published an input survey that mirrored the questions posed at the workshop to allow other stakeholders to provide their input, receiving nine responses suggesting 50 potential actions for consideration for the roadmap.



This word cloud displays the themes from survey respondents' suggestions for which actions to include in the roadmap.

MAPC then used the suggestions from the public and MAPC's Municipal Net Zero Playbook to create a long list of actions that the committee then narrowed down to the ones outlined here in the roadmap.

How can you be a net zero hero – ways to get involved

Reaching net zero by 2050 will be an all-hands-on deck effort! Here's a list of ways that you can do your part in helping us get there.

Peabody Resident

Share your voice, get involved, and act on choices in your control (e.g., complete an energy audit, insulate your home, go solar, switch to clean heating, make your next car electric) and participate in the local and state programs available to support you.

Peabody Small Business

Share your commitments with customers and staff. For those in a climate-adjacent field – such as electricians, HVAC specialists, plumbers – participate in the green economy and support "green growth" locally.

Larger Employer or Local Institution

Provide programs that assist employees in decarbonizing their homes and commute, and work with other large businesses to share experiences and support community-wide GHG emissions reductions.

Elected and Appointed Officials

Consider how the decisions your Board, Committee, or legislative body will impact Peabody's net zero goal. Advocate and vote to support policy or regulations that advance actions identified in the Net Zero Roadmap.

Municipal and School Staff

Lead by example with new public facility construction and renovation projects, and when possible, purchase zero emission fleet vehicles. Continue to make municipal buildings and schools as energy efficient as possible and add solar to new roofs as they are replaced.

Net Zero Roadmap

This roadmap was developed by the City of Peabody with support from MAPC and with input from community members. The actions outlined below have the highest potential to reduce GHG emissions in the near-to-medium term and will help set our community on the path to achieving net zero emissions. The actions are organized in the following categories:

 **BUILDINGS (B)**	**This section includes strategies to make our homes and buildings highly efficient and optimize clean energy for electricity, heating, and cooling.**
 **MOBILITY (M)**	This section tackles GHG emissions reductions from how our residents get around Peabody.
 **ENERGY (E)**	This section includes strategies to transition Peabody's energy to 100% renewable sources.
 **NATURAL SYSTEMS (N)**	This section promotes sustainable living through local food, air pollution reduction, green space creation, and recycling.
 **OTHER (O)**	This section includes other actions for Peabody to advance (e.g., outreach, education, sustainability officer, etc.).

Each section also includes a list of "additional actions for consideration." These actions will also help Peabody achieve net zero but were deemed to be less impactful in reducing emissions.

Buildings (B)

Peabody's buildings produce nearly two-thirds of total emissions and are the largest single source of greenhouse house gas pollution. Reducing emissions from buildings will be one of the most important steps to achieving net zero. Progress will depend **on achieving carbon-free electricity, converting as many building components to electricity** as possible, and dramatically **increasing energy efficiency**.

BUILDINGS: Strategy Summary	B1. Create and preserve efficient affordable housing
	B2. Partner on clean energy outreach programs
	B3. Provide clean energy financing options for Peabody residents
	B4. Require energy efficiency licensing for rental units and electrification incentives for building owners
	B5. Lead by example on municipal building performance
	B6. Develop an emissions performance standard
	B7. Adopt the Specialized Stretch Energy Code
	Other Actions for consideration

B1. Create and preserve efficient affordable housing

Improving the energy efficiency of a home or building is one of the fastest and most cost-effective ways to reduce energy demand, and therefore emissions. In 2021, Peabody released its Housing Production Plan (HPP) which identified the creation of new affordable rental units as a top priority, along with pursuing the redevelopment and substantial rehabilitation of existing affordable units.

To create and preserve efficient affordable housing, in concert with the goals included in the HPP, the City will:

Advocate for affordable housing. Peabody will promote the production and preservation of high-efficiency affordable housing by working with developers and local housing advocates, including housing that accommodates different family sizes and income levels.

Figure 1. North Shore CDC's Harbor Village, a Passive House-certified mixed-use development with 30 units of affordable housing in Gloucester, MA. Photo credit: North Shore CDC.

Encourage Building Standards. The City will encourage higher energy efficiency and performance building standards (e.g., Passive House) for new construction and retrofits while maintaining affordability for residents. Peabody will use equitable transit-oriented development (eTOD) principles to guide this approach.

Affordable Housing Trust Fund. To support these efforts, the City is considering establishing and capitalizing an Affordable Housing Trust Fund that will build local capacity to promote affordable housing. This fund will also be used to support continued funding to housing rehabilitation efforts. The City will be responsible for capitalizing the Trust Fund and designating an amount of Community Preservation Act funding per year to support affordable housing initiatives. In addition to establishing the Trust Fund, the City will dedicate effort to educating residents and local leaders of its benefits and creating guidelines to articulate the housing goals, eligible activities, and funding priorities of the Trust.

Establish protections to maintain affordability and prevent displacement. Energy efficiency retrofits can be disruptive and have the potential to temporarily or permanently displace residents. The City will establish protections to maintain affordability for current residents while energy retrofits are being completed and prevent displacement after completion.

Equity Considerations: Low-income residents and people of color, who have historically been excluded from homeownership, are most impacted by the current housing crisis. Low-income residents also face greater barriers to accessing resources for energy efficiency and other clean energy solutions (e.g., solar PV), including high upfront costs and program design that favors higher-income households, such as high credit score requirements. Implementation of this action will prioritize the needs of communities of color to ensure that the benefits of energy and water efficiency are distributed equitably to those who have been historically excluded. Peabody will be mindful of equitably distributing the funds and not excluding certain demographics (e.g., people with disabilities or those experiencing homelessness).

Lead Implementer: Department of Community Development and Planning

Partners: Peabody Housing Authority, North Shore Habitat for Humanity, North Shore HOME Consortium and Continuum of Care, Peabody Council on Aging, Peabody Community Development Authority

Timeline: Ongoing

B2. Partner on clean energy outreach programs

Lack of easily accessible education for consumers and trusted local advisors can limit adoption of clean energy technologies. To raise awareness for these technologies and the various forms of technical and financial aid available to residents and businesses, the City will partner with different departments and organizations to launch clean energy outreach campaigns and programs. Outreach programs can facilitate adoption of clean energy technologies by 1) making information easily accessible and understandable, and 2) reducing costs through group purchasing and bulk discounts.

Launch Outreach Programs & Campaigns. The City will study and replicate successful outreach campaign models from other leaders in the region, such as the Melrose Energy Challenge[2], the Solarize/Solarize Plus program supported by the Massachusetts Clean Energy Center (MassCEC), and the Weatherize model developed by the Island Institute and Vital Communities[3]. The City will explore opportunities to conduct combined campaigns for energy

[2] Melrose Is Greener than Ever | Melrose MA (cityofmelrose.org)
[3] Weatherize Upper Valley – Vital Communities

efficiency retrofits, solar PV, air source and ground source heat pumps, and electric vehicle charging stations. Additionally, a concerted effort will be placed on reaching underserved groups such as renters or moderate-income households who typically face greater barriers to participation in clean energy programs and households currently using expensive and inefficient oil, propane, or electric resistance heating systems.

Equity Considerations: Renters, moderate-income residents (those between 60% and 80% of State Median Income), and residents with limited English proficiency have historically been underserved by clean energy programs in Massachusetts. These same groups will continue to be underserved if there is not a concerted effort by communities, service providers, and program administrators to form partnerships that address the barriers to undertaking clean energy upgrades. With such an effort to build partnerships that address access barriers, the benefits of this action can be distributed broadly and equitably across the community.

Lead Implementer: Sustainability staff and/or Committee

Partners: solar installers, energy efficiency/home performance contractors, MAPC, local environmental groups, utilities/Mass Save Program Administrators, MassCEC.

Timeline: Intermediate term

B3. Provide clean energy financing options for Peabody residents

The City and Peabody Municipal Light Plant (PMLP) will explore options for providing residents and businesses with financing options for clean energy solutions, including a revolving loan fund and "tariffed on-bill financing." MMWEC and its members are exploring on-bill financing programs. PMLP could adopt such a program, enabling its customers to finance energy upgrades with loans that are paid back through the savings on their energy bills. Local governments can establish revolving loan funds to provide low-interest loans to support energy retrofits and other home upgrades.

Lead implementer: PMLP, Sustainability staff

Partners: MMWEC

Timeline: Short term

B4. Require energy efficiency licensing for rental units and provide electrification incentives to building owners

A notable barrier to energy efficiency and electrification upgrades is the "split incentive," which occurs when a building owner or manager is hesitant to invest in upgrades because only the building occupant will experience the benefits of lower utility bills, resilience, quality of life, etc. Energy efficiency licensing in rental units and electrification incentives for building owners are two opportunities to address the split incentive challenge.

Energy Efficiency Licensing. Rental licensing promotes energy efficiency in existing buildings by requiring that certain actions, such as energy audits and weatherization, be implemented in rental properties, and that rental properties pass a regular inspection, such as at the point of leasing. The City can establish requirements within the rental licensing process for landlords to

make energy efficiency upgrades and will determine a standard interval for inspections. This approach can start with a voluntary program that ramps up to a requirement over time.

Electrification Incentives. Building owners who switch to electric alternatives may be eligible for financial incentives (e.g., rebates, grants, low-interest loans, property tax incentives, etc.) to offset the cost of transitioning from fossil fuel-based heating, cooling, and hot water systems to cleaner, electric options either through PMLP or through the federal government. For example, the federal Inflation Reduction Act of 2022 established multiple incentives for electrifying homes including tax credits and rebates.

Equity Considerations: Energy efficiency licensing for rental units should be paired with protection for renters so that they are not displaced by resulting improvements to the property. Municipalities enacting this action should enact complementary policies and programs, such as renter protections, free renter legal aid, and renter support phone-lines. Additionally, electrification incentives must ensure all building owners have access to information and resources in order to participate. The City will consider offering information sessions, technical assistance, or financial advising to support building owners, particularly lower-income owners, make the transition.

Lead Implementer: Inspectional Services Department

Partners: Housing Department, Energy Manager, Renters, Property Owners, Advocacy and Consumer Protection Organizations, Board of Health

Timeline: Intermediate term

B5. Lead by example on municipal building performance

Municipal buildings present an important opportunity for the City to reduce emissions while leading by example in demonstrating the feasibility and appeal of net zero buildings to the broader community.

Adopt a Net Zero Standard for New Municipal Buildings. The City will develop and adopt a policy that requires higher levels of energy efficiency and renewable energy generation in municipally owned and funded buildings, including a net zero standard for new construction. This process will also set broader sustainability metrics for public projects.

Plan for and Retrofit Municipal Buildings. The City will conduct energy audits of the municipal building stock to identify the most inefficient buildings and prioritize target buildings for improvements. This will include a near-term, multi-year plan and timeline for implementing these projects. The City will then phase out a series of retrocommissioning/deep energy retrofit projects (e.g., whole-building insulation or air sealing improvements) in all municipally-owned buildings. Retrocommissioning work involves a close examination of existing energy systems and recommendations on improvements to ensure efficient operations and building envelope. As feasible, on-site renewable energy should be included (see *Strategy E1. Maximize renewable energy generation on municipal property*).

Train Staff & Spread the Word. The City will train relevant staff on the new net zero standards and design. As retrofits and renewable energy projects are completed, promote and showcase these municipal buildings as models for other buildings in the community.

Equity Considerations: Public housing has been underfunded for decades, and residents often live in inefficient, unhealthy housing. The benefits of net zero buildings can be distributed across the entire community if municipal buildings and public housing are built to net zero standards. Peabody will also lead by example in the development and sustainability of the affordable housing trust fund (see *B1. Create and preserve efficient affordable housing*).

Lead Implementer: City Council

Partners: Inspectional Services Department, Facilities Department, School Department, Housing Authority

Timeline: Ongoing

B6. Develop an emissions performance standard

Building performance standards (BPS) are policy mechanisms that municipalities and states can use to set high-level thresholds for building performance while not prescribing exactly how each building must meet the emissions performance standard.

Adopt a building energy disclosure policy. Energy disclosure policies are important enabling actions that many communities are already using to drive emissions reductions in the building sector across New England and throughout the United States. The City will require large buildings above a certain size to report their energy use annually, with appropriate enforcement mechanisms and requirements to reduce emissions over time and evaluate BPS use cases to determine the best structure, thresholds, and timeline for your community's building stock.

Determine Compliance and Enforcement Mechanisms. Compliance may take the form of requiring building developers to benchmark the building's operational emissions each year. Noncompliance may be addressed through fines or alternative compliance payments, both of which could be collected by the municipality to help support low- to moderate-income building owners and EJ communities to comply with the overlay.

Equity Considerations: To avoid negatively impacting low-income residents and other vulnerable populations, such a standard should be designed carefully with these groups in mind. For example, an emissions performance standard should give building owners enough lead time to ensure that they can meet the standard without displacing tenants. The benefits of such a standard – such as lower energy costs and increased resiliency - should also be accessible to these vulnerable populations. For example, instead of exempting affordable housing from the standard, work with affordable housing owners and developers to ensure that the policy is structured in a way that allows them to participate.

Lead Implementer: Select Board/City Council

Partners: Planning Department, Energy Manager, Zoning Board, Planning Board, Inspectional Services Department, Building Owners

Timeline: Long term

B7. Adopt the Specialized Stretch Energy Code

The Specialized Stretch Energy Code is a voluntary alternative to the state building code that promotes more energy-efficient buildings while reducing energy consumption and building

emissions. The alternative Code ensures that the City's new construction and major renovations are not locked into high emissions for years into the future. The Code includes requirements for increased levels of insulation, more efficient heating and cooling systems, improved window performance, and provisions for renewable energy (e.g., solar panels) to offset energy consumption.

Advocate for and Adopt the Code. In order to formally adopt the Code, City Council must actively vote to opt-in. The requirements will take effect six months after the vote to allow for a smooth transition to the new Code. Adoption of the Code will also make it easier for Peabody to receive Green Communities designation, bringing a number of benefits, such as technical and financial assistance for local energy projects.

Raise Awareness. Upon adoption, the City will train City code officials and work closely with stakeholders (e.g., building owners, developers, designers, and managers) to raise awareness of the new requirements.

Equity Considerations: Higher energy-efficiency standards may result in costs being passed onto renters in the form of higher rent. The City will empower community organizations and EJ populations to weigh-in on the code development process and voice any concerns to support the City in proactively addressing any equity concerns.

Lead Implementer: City Council

Partners: Inspectional Services Department, MAPC, Department of Energy Resources, NEEP, MCAN, Sierra Club, Built Environment Plus, New Buildings Institute, Energy Efficient Codes Coalition

Timeline: Short term

Additional actions for consideration

- Require all new construction and roof replacements to implement an "eco-roof" (green roof)
- Offer expedited permitting and reduced permitting fees for net zero emissions buildings and net zero enabling technologies
- Tighten building code in terms of allowed actions. Look to site plan review as inflection point
- Translate programs for apartment and condo complexes in the city

Mobility (M)

Transportation accounts for more than one-third of Peabody's total greenhouse gas emissions. **Electrifying our transportation system** and giving people **more and better choices about how they get around** are key strategies to achieving net zero. The following actions will help us get there.

MOBILITY: Strategy Summary	M1. **Reduce vehicle miles traveled**
	M2. **Accelerate electrification of vehicles by expanding EV charging access community-wide**
	M3. **Lead by example by transitioning municipal vehicle fleet to zero-emissions vehicles**
	M4. **Advocate for systems change that enables zero-emission mobility**
	Additional Actions for consideration

M1. Reduce vehicle miles traveled

Reducing vehicle miles traveled (VMT) is one of the most direct ways to reduce transportation emissions. The City can reduce VMT by making other modes of transportation, like walking, bicycling, and public transportation more appealing and more accessible to residents.

Develop and implement a bike and pedestrian plan. Robust pedestrian, bicycle, and green infrastructure throughout a community's street network is critical to making carbon-free choices the most appealing and feasible option for residents. The City will develop a bike and pedestrian plan to identify gaps in the transportation network and make recommendations on how to improve bicycle and pedestrian safety and connectivity on major regional corridors and local routes with high access to important destinations.

Adopt a Complete Streets policy. The City will adopt a Complete Streets policy that commits to implementing projects to improve safety and convenience for residents who choose to bike, walk, or take public transportation, prioritizing children, older adults, and people with disabilities.

Adopt climate-smart parking policies. The City will consider a suite of data-driven policies and strategies to encourage more efficient allocation of parking resources, including those outlined in MAPC's Municipal Net Zero Playbook.

Equity Considerations: The geographic distribution of investments in transportation infrastructure is tied to equitable access to zero emission modes of transportation as a safe and convenient mobility option. The City will support the development of this strategy with community engagement that meets vulnerable populations within the community where

they are and provides these vulnerable groups with a role in the decision-making process to guide investment in infrastructure.

Lead Implementer: Planning Department

Partners: City Council, Planning board, MAPC, MassDOT

Timeline: Intermediate term

M2. Accelerate electrification of vehicles

As more people shift to driving electric vehicles (EVs), this will reduce GHG emissions in the transportation sector. Currently, EVs are the most widely available zero emission vehicle option on the market. The City will expand EV charging access community-wide by investing in public EV charging stations in high-traffic areas and promote EV adoption through policies and education efforts.

Invest in public charging stations. The City will identify strategic areas to install EV charging stations at public facilities to provide greater access to charging and supplement existing charging infrastructure (e.g., the North Shore Mall).

Adopt EV charging site guidance. The City will specify requirements for stations, signage, and wayfinding for both on- and off-street parking, alongside regulations and enforcement policies for EV parking spaces.

Implement an EV car sharing program. The City will explore private partnerships or a regional collaboration with neighboring communities to implement a car sharing program that provides access to EVs for those who do not own their own vehicles. Local examples to look to include Boston's Good2Go[4] and the Salem Skipper shuttle[5] (not electric but may be in the future).

Promote local education and awareness of electric vehicles. The City will provide informational resources and conduct outreach to residents to encourage EV adoption with a focus on providing opportunities that make EVs more affordable for residents. This may include partnering with PMLP to provide incentives for EVs and working with local car dealerships to host EV ride and drive events.

Equity Considerations: Many of the early adopters of electric vehicles in Massachusetts have been predominantly male, affluent, and highly educated.[6] There are two primary considerations that will guide municipal investments in public charging stations: strategic geographic placement of charging stations and programs to reduce economic barriers to EV adoption. The deployment of charging stations will be paired with promotion of available incentives, creation of additional funding support, and car sharing models.

Lead Implementer: Sustainability staff/Planning Department

[4] https://evgood2go.org/
[5] https://www.salemma.gov/mobility-services/pages/salem-skipper
[6] "MOR-EV Year Three Report (July 2016 – October 2017)," Center for Sustainable Energy, October 2018, https://mor-ev.org/sites/default/files/docs/MOR-EV_Year_Three_Report.pdf

Partners: Public Services Department, local car dealers, Green Energy Consumers Alliance, car share companies

Timeline: Intermediate term

M3. Lead by example by transitioning municipal vehicle fleet to zero-emissions vehicles

The City can play an important role in leading the way on adopting electric vehicles by transitioning its vehicle fleet over time.

Adopt a zero emission municipal fleet policy. Peabody will develop a municipal fleet policy that sets zero emissions standards, or as low as possible, if zero emissions options are not currently feasible, for new acquisitions and leased vehicles. The MAPC Net Zero Playbook recommends that municipalities fully transition to electric vehicles by 2030 for all types of vehicles, as viable electric alternatives become available.

Procure/deploy electric school and shuttle buses. Peabody will explore purchasing electric buses through the Environmental Protection Agency's Clean School Bus Program[7] or with support from other state and federal programs. Electric school and shuttle buses produce the co-benefits of reduced air pollutant exposure for students/passengers and increased resiliency of the electric grid. The City will consider working with neighboring municipalities to explore the potential for collective procurement of electric buses, which can provide additional cost and time saving benefits.

An electric school bus in Beverly, MA. Photo credit: Brooks Winner, MAPC.

Lead Implementer: City Council/Peabody Public Schools

Partners: EPA, MAPC, other municipalities

Timeline: Ongoing

[7] https://www.epa.gov/cleanschoolbus

M4. Advocate for systems change that enables zero-emission mobility

Advocate for community and regional transit needs. Peabody will explore opportunities to connect city transportation networks to surrounding communities like Salem and address last-mile connection issues that make transit access challenging, including by exploring adding shuttle buses to train stations. The City will advocate for local bus and railway service priorities and fleet electrification during upcoming planning processes with the Boston Region Metropolitan Area Planning Organization (MPO) and the Massachusetts Department of Transportation (MassDOT). The City will also coordinate with community partners to identify the priority list of service improvements that will increase frequency and reliability of service to underserved areas and provide access in transit service deserts (areas with no access to buses or trains).

Advocate for and implement utility rate design changes. PMLP will explore changes to its rates that encourage electric vehicle charging at times that don't contribute to peak demand on the grid.

Equity Considerations: Access to efficient and reliable public transportation is systemically worse for people of color as a result of spatial segregation and a history of unjust transportation planning policies. As the City works to improve community access to transit service through the Peabody Net Zero Roadmap, the voices and needs of people of color and other marginalized groups will be central throughout the engagement, planning, and decision-making processes to acknowledge past and current injustices and build greater access to opportunity.

Lead Implementer: City Council/Sustainability staff

Partners: MAPC, Boston Region MPO, MBTA, MassDOT

Timeline: Short term

Additional actions for consideration

- Improve public transportation to Boston
- Engage with transportation network companies and develop partnerships to encourage increased adoption of EVs
- Leverage funding provided by the federal government that can help the city purchase EV infrastructure

Energy (E)

There is no path to achieving net zero GHG emissions without dramatically changing where our energy comes from and how we use it. **Switching to carbon-free energy sources**, such as renewable electricity, and **producing more energy locally** will help reduce emissions in Peabody. The following actions will help us get there.

ENERGY: Strategy Summary	E1. Maximize renewable energy generation on municipal property
	E2. Offer community-based clean energy options
	E3. Collaborate with utilities to further renewables and mitigate emissions
	E4. Promote clean energy through zoning and permitting
	E5. Advocate for clean energy policies that increase access and accelerate the transition to net zero
	Other Actions for consideration

E1. Maximize renewable energy generation on municipal property

Renewable energy installations reduce the GHG emissions of the municipal portfolio while allowing the City to lead by example and inspiring other organizations and individuals to follow suit. Municipalities can install solar PV in multiple configurations – on municipal rooftops, as parking canopies, or as ground-mounted installations. They can also install other renewables, such as wind turbines, solar thermal systems for hot water heating in municipal buildings, and geothermal generation via ground source heat pumps.

This includes installation of all viable rooftop solar, solar canopies, and ground-mounted solar PV systems. It can also include solar thermal, wind, or geothermal generation.

Conduct feasibility study and procure clean energy. Select a vendor to conduct a feasibility study of all municipally owned sites for renewable energy potential. Based on the results, prioritize and procure renewable energy installations for viable locations.

Raise awareness. Conduct outreach and education in your community once renewable energy projects are installed to increase awareness. This could include offering tours of the installation and information about how residents can install renewable energy on their homes.

Equity Considerations: The City should consult community members to understand their priorities for installations, especially those that affect community centers, schools, and open space. For vacant lot space, municipalities should consider other community priorities for that land, such as affordable housing and public parks, and consider how renewable energy could be included in those projects.

Lead Implementer: Facilities Department

Partners: PMLP, Mayor, City Council, energy auditor, School Superintendent and Board

Timeline: Intermediate term

E2. Offer community-based clean energy options

There are a number of barriers that can hinder residents from making the transition to clean energy including financial constraints, lack of information or technical expertise, and limited access to clean energy technologies. PMLP will develop clean energy programs, including an opt-in renewable energy purchasing program, to make adoption more feasible and accessible for customers.

Renewable Energy Purchasing Program. PMLP will establish a renewable energy purchasing program to provide residents the option to purchase 100% renewable energy similar to those implemented by other municipal light plants, including the Marblehead Municipal Light Department's Go Green Now![8] program.

Lead Implementer: PMLP

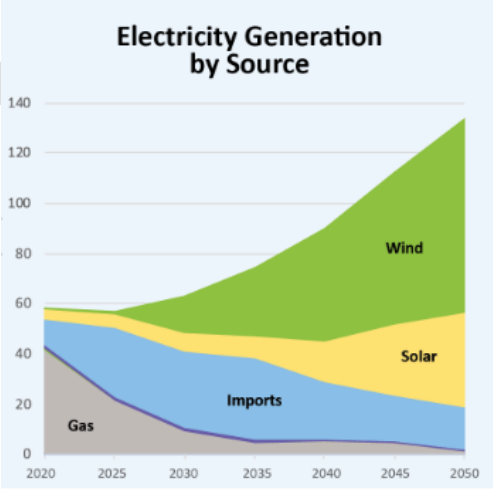
Partners: Community groups and organizers, low-income residents, electric utility, public housing authority

Timeline: Short term

E3. Collaborate with utilities to further renewables and mitigate emissions

Peabody will collaborate with the local utilities, including PMLP and National Grid, to further advance the use of renewable energy sources as well as mitigate emissions from major gas leaks.

Support PMLP with net zero commitments & incentives. PMLP's 2050 Decarbonization Roadmap outlines the utility's plan for transitioning its energy portfolio to 100% clean energy by 2050. As of 2020, 42% of PMLP's energy supply was net-zero, and by 2030, this number is expected to climb to 56%.[9] PMLP will explore opportunities to procure offshore wind and other renewable energy sources to achieve a net zero electricity portfolio.



PMLP's projected electricity generation mix between 2020 and 2050. Source: PMLP

Address major gas leaks. Repairing gas leaks improves residents' health, makes the gas network more efficient, and helps to eliminate difficult-to-account-for GHG emissions. Peabody is working with National Grid to mitigate major gas leaks, like methane. The City will work with National Grid to develop and advance a plan to repair or replace aging infrastructure and implement new technologies to detect and prevent leaks. In addition, Peabody will work to align internal policy to coordinate municipal paving, water, and sewer infrastructure planning efforts and consider joining collaborating with other municipalities on this issue through the Multi-Town Gas Leaks Initiative.

[8] https://marbleheadelectric.com/go-green-now.html
[9] PMLP's Decarbonization Roadmap

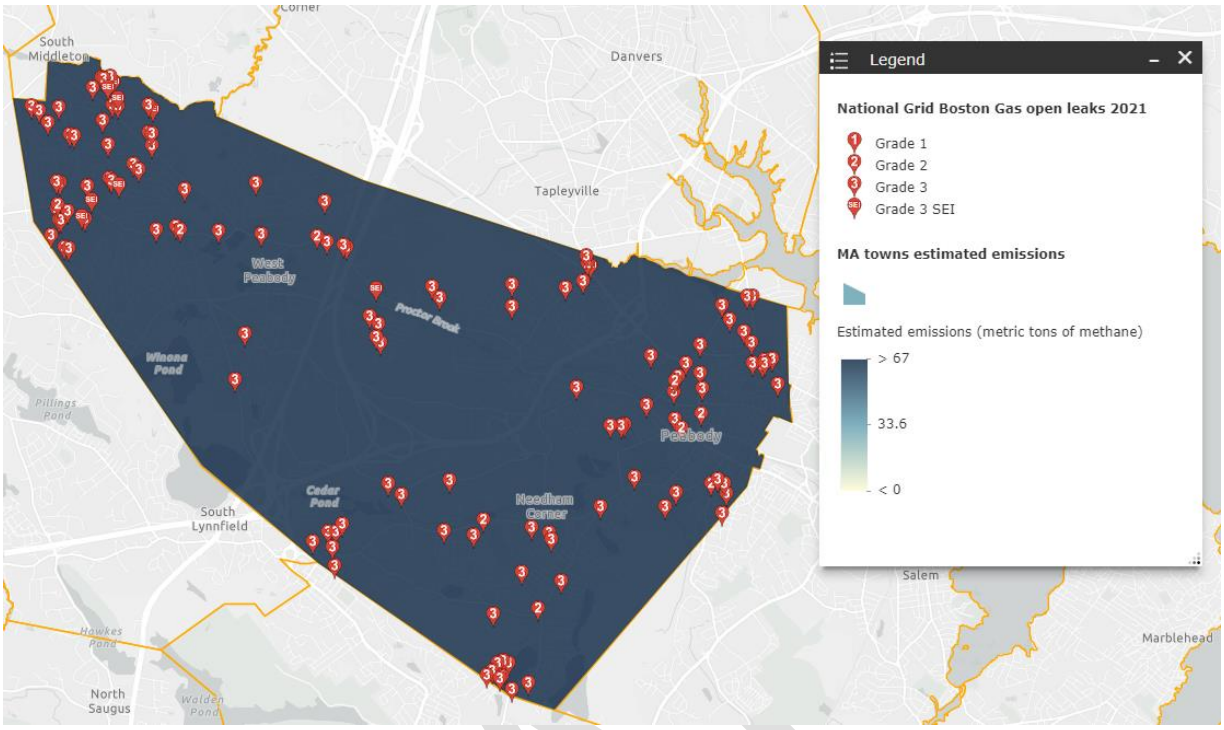


Figure 2. Map of National Grid's open gas leaks in Peabody as of 2021. Data from the Home Energy Efficiency Team (HEET) Annual Leaks Map. https://heet.maps.arcgis.com/apps/webappviewer/index.html?id=73f7627766e64161a65c7518acb7eb9d

Equity Considerations: The City will collaborate with PMLP to ensure equity is embedded into the utility's net zero strategy and incentives. For instance, incentives will be designed to ensure access to lower income residents and renters are considered, community-based organizations are engaged in planning and decision-making conversations, and financing options are available. For natural gas leaks, the City will advocate for and prioritize fixing leaks that are located near communities of color, low-income residents, and other populations that have historically suffered disproportionately from environmental harms.

Lead Implementer: Sustainability staff

Partners: PMLP, National Grid, Department of Public Utilities, Multi-Town Gas Leaks Initiative

Timeline: Ongoing

E4. Promote clean energy through zoning and permitting

Zoning and permitting can be utilized as a strategy to increase the adoption of solar, wind, and other forms of renewable energy in buildings city-wide. This approach makes it easier for developers to add clean energy projects by streamlining the permitting process and providing incentives for renewables in designated zones.

The Guide to Streamlining the Solar PV Permitting Process and Developing Supportive Zoning Bylaws is a solar permitting and zoning toolkit developed by MAPC to support municipalities in increasing solar adoption across their community.[10]

[10] https://www.mapc.org/wp-content/uploads/2017/11/Solar-Permitting-and-Zoning-Bylaws.pdf

Incentivize clean technologies through special permits. Peabody has the authority to incentivize the inclusion of additional amenities to be able to grant a special permit. Solar energy systems or clean heating and cooling technologies could be required for developers applying for a special permit. Peabody will create guidance for the Special Permit Granting Authority on clean heating and cooling technologies amenities and provide information at special permit hearings. Once familiarity has increased, clean heating/cooling can be a requirement for a special permit.

Streamline permitting for net zero buildings. The City will offer expedited permitting and reduced permitting fees for net zero emissions buildings and net zero enabling technologies. This approach encourages net zero construction and technologies by providing a transparent, easier, and/or less expensive permitting process. The City will first assess the current permitting pathway for net zero buildings and technologies and identify opportunities for expedited permitting and reduced permitting fees. A net zero zoning guide and permitting checklist would make it easy for developers to follow new policies and create consistency.

Equity Considerations: To ensure that low-income residents, communities of color, and other populations that are disproportionately affected by poor indoor and outdoor air quality are beneficiaries of this action, the City will consider equity indicators in the permitting process, prioritize permitting for multi-family buildings, or provide financial or technical assistance for those populations adopting clean heating and cooling technology. In developing streamlined permitting processes, the City will prioritize feedback from developers that are minority and women-led businesses. Municipalities should consider increasing the available incentives for multi-family buildings and retrofits to encourage greater adoption of net zero enabling technologies and systems in hard-to-reach buildings.

Lead Implementer: Planning Department

Partners: Zoning Board, Inspectional Services Department

Timeline: Intermediate term

E5. Advocate for clean energy policies that increase access and accelerate the transition to net zero

The transition to a clean energy future must be just and ensure that low-income communities, communities of color, and other populations on the frontlines of experiencing climate impacts can fully participate and directly benefit. Peabody will advocate for policies that center justice and accelerate the net zero transition.

Support legislation and regulations that advance environmental and energy justice. Peabody will monitor and advocate for such policies, such as through preparing advocacy letters, providing written and oral testimony, and meeting with legislators. Additionally, the City will keep in touch with MAPC and peer municipalities on state and local equity-centered clean energy and climate policy advocacy, looking to MAPC's Health, Housing, Energy, Equity training series as a starting point.[11]

[11] https://www.mapc.org/resource-library/aarc-training/

Lead by example by designing programs that engage EJ communities. The City will design clean energy programs that encourage and support participation of EJ communities. This may include encouraging the establishment of a clean energy community benefits fund and/or a commission on energy justice to direct benefits to EJ communities. This fund could support renewable energy installations and energy efficiency projects, clean energy jobs training, and green infrastructure projects for EJ communities.

Collaborate with local, state, and utility partners. Peabody will work with local, state, and utility partners to advocate for policies that encourage energy efficiency and clean technologies communitywide and actively advocate against policies that promote technologies expected to become obsolete or decommissioned in a short time span.

Equity Considerations: The Commission would oversee the fund's implementation and coordinate with DOER and the DPU to ensure equitable structures and benefit distribution within statewide programs.

Lead Implementer: Sustainability staff

Partners: MAPC, PMLP

Timeline: Ongoing

Additional actions for consideration

- Pursue SolSmart designation to receive no-cost technical assistance from DOE in reducing the soft costs and other barriers of solar adoption for residents, businesses, and community-based organizations.

Natural Systems (N)

To help our community reach net zero and increase our climate resilience, among other co-benefits, we should work to implement strategies that **support local foods, promote nature-based solutions, and reduce waste.**

NATURAL SYSTEMS: Strategy Summary	N1. Make local food more accessible through affordable farmers markets, mobile markets
	N2. Support air pollution monitoring and mitigation
	N3. Create and restore green spaces
	N4. Increase waste reduction methods in the community
	Additional Actions for consideration

N1. Make local food more accessible through affordable farmers markets, mobile markets

The City will identify opportunities to increase access to locally sourced food through the implementation of affordable farmers markets and mobile markets. While not directly accounted for in Peabody's GHG inventory, this strategy also indirectly reduces emissions from industrial agriculture and long-distance food transportation. Additionally, this approach will boost the resilience of local food systems by allowing Peabody to be less vulnerable to disruptions in the global food supply chain.

Equity Considerations: The availability and affordability of healthy, fresh food is often limited in lower-income neighborhoods and communities of color, leading to food insecurity and health disparities. The City must ensure that the locations of farmers markets and mobile markets are accessible to all residents, regardless of income or location. SNAP accessibility is also an important equity consideration for accessing healthy and affordable food options.

Lead Implementer: Brooksby Farm, Tillie's Farm, Newhall Fields Community Farm

Partners: Office of Community Development

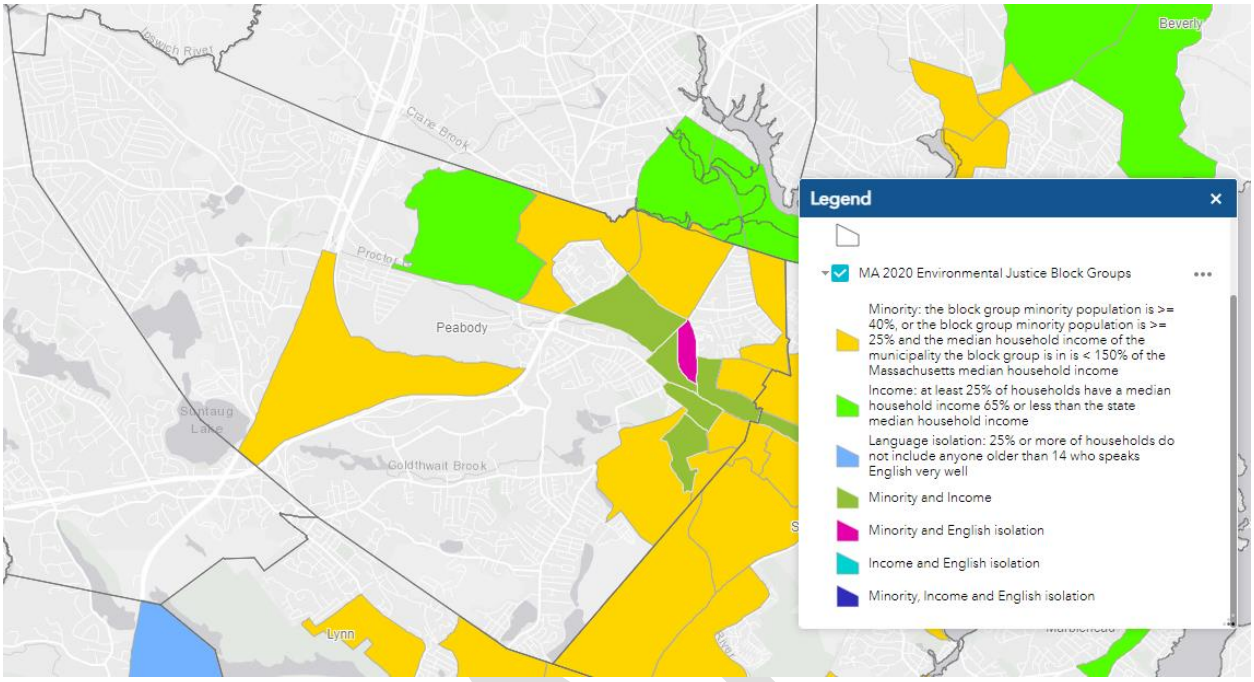
Timeline: Intermediate term

N2. Support air pollution monitoring and mitigation

Greenhouse gases caused by the burning of fossil fuels not only contribute to climate change, but also have direct impacts on human health through worsening air quality. Long term exposure to air pollution can cause chronic health issues and affect vulnerable populations (e.g., children, the elderly, people with pre-existing health conditions) more severely.

Monitor air pollution. Peabody will explore the implementation of a comprehensive, real-time air pollution monitoring network. This network will provide real-time data on air pollution levels throughout the city, allowing city officials to better understand the sources and types of pollutants and take targeted action to reduce them.

Pilot programs to improve air quality. After identifying major sources of air pollution, the City will pilot programs to improve air quality. For example, Peabody will explore a grant program to distribute air purifiers in the most polluted neighborhoods and an education campaign for residents to take advantage of available resources for pollution reduction.



Peabody has 15 environmental justice block groups, shown in the map above generated using the Massachusetts 2020 Environmental Justice Populations mapping tool available here. Air pollution monitoring and reduction efforts will aim to reduce impacts on these communities.

Equity Considerations: Implementation of a comprehensive, real-time air pollution monitoring network must be accessible to all communities, especially those most impacted by pollution, such as children, the elderly, and those with pre-existing health conditions. Additionally, the pilot programs to improve air quality should prioritize equitable distribution of resources, such as air purifiers, to those most in need.

Lead Implementer: Community Development

Partners: Diversity, Equity, and Inclusion (DEI) Coordinator, MAPC, US EPA

Timeline: Ongoing

N3. Create and restore green spaces

Green spaces, such as parks, forests, community gardens, green roofs, and other largely vegetated spaces, can help mitigate climate change by sequestering excess carbon dioxide from the atmosphere. In addition to carbon sequestration, green spaces can also help lessen the impacts of climate change by offering shade and cooling from extreme heat and reducing flooding by absorbing excess flood waters.

The City will explore additional green space strategies, such as a municipal parks bond, a dedicated green infrastructure plan, a green area ratio standard, and setting green area targets.

Create and Restore Green Spaces. The City will engage with community members to plan and design new and restore existing green spaces, being mindful of local needs and cultural and historic sensitivities. Green spaces will prioritize native and resilient plants.

Develop Maintenance Plan. To ensure green spaces are sustainable, well-maintained, and safe locations for residents to visit, the City will create a maintenance plan that includes funding sources to ensure regular upkeep and identifies partnership opportunities with local community groups to aid in the maintenance and awareness.

Equity Considerations: Accessibility and equity will be key criteria for setting up new green space locations, ensuring they are within reasonable walking distance of homes and public transit. The City will prioritize green spaces in low-to-moderate-income neighborhoods and engage residents in these communities throughout the planning and design process.

Lead Implementer: Community Development

Partners: Parks, Recreation, and Forestry Department; Community Preservation Committee; state agencies

Timeline: Intermediate term

N4. Increase waste reduction methods in the community

Waste in landfills can produce methane, a potent greenhouse gas. In Peabody, waste is responsible for nearly 6,000 metric tons of carbon dioxide equivalent (MT CO2e). The City will take measures to decrease the amount of waste sent to landfills by improving the efficiency of waste management and through community outreach to increase recycling (including textile recycling), composting, and other waste reduction methods.

Equity Considerations: Outreach and education efforts must prioritize access to ensure that all residents, regardless of income or location, have access to waste reduction methods such as recycling and composting.

Lead Implementer: Department of Public Services

Partners: Peabody Public Schools, MA Department of Environmental Protection, Green Peabody

Timeline: Ongoing

Additional actions for consideration

- Promote the usage of land for regenerative agriculture and pollinator farms
- Offer composting in schools and implement initiatives, such as meatless Mondays, to help reduce our food-related emissions

Other Actions (O)

There are additional steps we can take to reach net zero broadly.

O1. Hire a Sustainability Coordinator

Many municipalities in the Greater Boston region have hired at least one full-time staff position to support local sustainability efforts and the implementation of their climate action plans. Such positions help coordinate work across municipal departments and throughout the community and can also raise money for projects through grants and other sources. The City will explore ways to hire a sustainability coordinator or sustainability manager, including through a regional or multi-town collaboration to oversee the implementation of the Net Zero Roadmap and equitable community engagement around climate issues.

Lead implementer: City Council, DEI Coordinator

Partners: MAPC,[12] Northeast Energy Efficiency Partnerships (NEEP)[13]

Timeline: Intermediate term

[12] http://www.mapc.org/wp-content/uploads/2017/11/Shared-Energy-Manager.pdf

[13] NEEP's Achieving Community Efficiency (ACE) Project focused on supporting small, medium, and rural communities in to increase energy affordability, reliability, and resiliency and included the development of a model for shared energy manager positions. Learn more at https://neep.org/blog/top-seven-things-know-about-ace

Appendix A – Action Summary Table

Short term: Less than one year, **Intermediate term:** 1-5 years, **Long term:** 5 years or more; **Ongoing:** currently underway

STRATEGY & TIMELINE	LEAD	PARTNERS	TIMELINE
BUILDINGS (B)			
B1. Create and preserve efficient affordable housing • Advocate for affordable housing • Encourage Building Standards • Affordable Housing Trust Fund • Establish protections to maintain affordability and prevent displacement	Department of Community Development and Planning	Peabody Housing Authority, North Shore Habitat for Humanity, North Shore HOME Consortium and Continuum of Care, Peabody Council on Aging, Peabody Community Development Authority	Ongoing
B2. Partner on clean energy outreach programs • Launch Outreach Programs & Campaigns	Sustainability staff and/or Committee	solar installers, energy efficiency/home performance contractors, MAPC, local environmental groups, utilities/Mass Save Program Administrators, MassCEC	Intermediate term
B3. Provide clean energy financing options for Peabody residents	PMLP, Sustainability staff	MMWEC	Short term
B4. Require energy efficiency licensing for rental units and provide electrification incentives to building owners • Energy Efficiency Licensing • Electrification Incentives	Inspectional Services Department	Housing Department, Energy Manager, Renters, Property Owners, Advocacy and Consumer Protection Organizations, Board of Health	Intermediate term
B5. Lead by example on municipal building performance • Adopt a Net Zero Standard for New Municipal Buildings • Plan for and Retrofit Municipal Buildings • Train Staff & Spread the Word	City Council	Inspectional Services Department, Facilities Department, School Department, Housing Authority	Ongoing
B6. Develop an emissions performance standard • Adopt a building energy disclosure policy • Determine Compliance and Enforcement Mechanisms	Select Board/City Council	Planning Department, Energy Manager, Zoning Board, Planning Board, Inspectional Services Department, Building Owners	Long term
B7. Adopt the Specialized Stretch Energy Code • Advocate for and Adopt the Code • Raise awareness	City Council	Inspectional Services Department, MAPC, Department of Energy Resources, NEEP, MCAN, Sierra Club, Built Environment Plus, New Buildings Institute, Energy Efficient Codes Coalition	Short term

STRATEGY & TIMELINE	LEAD	PARTNERS	TIMELINE
MOBILITY (M)			
M1. Reduce vehicle miles traveled • Develop and implement a bike and pedestrian plan • Adopt a Complete Streets policy • Adopt climate-smart parking policies	Planning Department	City Council, Planning board, MAPC, MassDOT	Intermediate term
M2. Accelerate electrification of vehicles by expanding EV charging access community-wide • Invest in public charging stations • Adopt EV charging site guidance • Implement an EV car sharing program • Promote local education and awareness of electric vehicles	Sustainability staff/Planning Department	Public Services Department, local car dealers, Green Energy Consumers Alliance, car share companies	Intermediate term
M3. Lead by example by transitioning municipal vehicle fleet to zero-emissions vehicles • Adopt a zero emission municipal fleet policy • Procure/deploy electric school and shuttle buses	City Council/Peabody Public Schools	EPA, MAPC, other municipalities	Ongoing
M4. Advocate for systems change that enables zero-emission mobility • Advocate for community and regional transit needs • Advocate for and implement utility rate design changes	City Council/Sustainability staff	MAPC, Boston Region MPO, MBTA, MassDOT	Short term
ENERGY (E)			
E1. Maximize renewable energy generation on municipal property • Conduct feasibility study and procure clean energy • Raise awareness	Facilities Department	PMLP, Mayor, City Council, energy auditor, School Superintendent and Board	Intermediate term
E2. Offer community-based clean energy options • Renewable Energy Purchasing Program	PMLP	Community groups and organizers, low-income residents, electric utility, public housing authority	Short term
E3. Collaborate with utilities to further renewables and mitigate emissions • Support PMLP with net zero commitments & incentives • Address major gas leaks	Sustainability staff	PMLP, National Grid, Department of Public Utilities, Multi-Town Gas Leaks Initiative	Ongoing

STRATEGY & TIMELINE	LEAD	PARTNERS	TIMELINE
E4. Promote clean energy through zoning and permitting • Incentivize clean technologies through special permits • Streamline permitting for net zero buildings	Planning Department	Zoning Board, Inspectional Services Department	Intermediate term
E5. Advocate for clean energy policies that increase access and accelerate the transition to net zero • Support legislation and regulations that advance environmental and energy justice • Lead by example by designing programs that engages EJ communities • Collaborate with local, state, and utility partners	Sustainability staff	MAPC, PMLP	Ongoing
NATURAL SYSTEMS (N)			
N1. Make local food more accessible through affordable farmers markets, mobile markets	Brooksby Farm, Tillie's Farm, Newhall Fields Community Farm	Office of Community Development	Intermediate term
N2. Support air pollution monitoring and mitigation • Monitor air pollution • Pilot programs to improve air quality	Community Development	DEI Coordinator, MAPC, USA EPA	Ongoing
N3. Create and restore green spaces • Create and Restore Green Spaces • Develop Maintenance Plan	Community Development	Parks, Recreation, and Forestry Department; Community Preservation Committee; state agencies	Intermediate term
N4. Increase waste reduction methods in the community	Public Services	Peabody Public Schools, MA Department of Environmental Protection, Green Peabody Group	Ongoing
OTHER (O)			
O1. Hire a Sustainability Coordinator	City Council	MAPC,[14] Northeast Energy Efficiency Partnerships (NEEP)[15]	Intermediate term

[14] http://www.mapc.org/wp-content/uploads/2017/11/Shared-Energy-Manager.pdf

[15] NEEP's Achieving Community Efficiency (ACE) Project focused on supporting small, medium, and rural communities in to increase energy affordability, reliability, and resiliency and included the development of a model for shared energy manager positions. Learn more at https://neep.org/blog/top-seven-things-know-about-ace

Appendix B - Peabody's Greenhouse Gas Inventory Methodology

The City of Peabody used the Metropolitan Area Planning Council's (MAPC) Community Greenhouse Gas Inventory Tool ("the Tool"). This technical documentation summarizes the inventory methodology used for the Tool and the supporting data sources for Peabody's GHG Inventory. The inventory methodologies are described in detail by sector and subsector.

Methodology Basics

The Tool is designed to enable communities in Massachusetts to complete a community-wide inventory that follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories ("Global Protocol") which was developed by the World Resources Institute, C40 Cities, and ICLEI Local Governments for Sustainability and is required by The Global Covenant of Mayors for Climate and Energy (Global Covenant).[16]

EMISSION SECTORS AND SOURCES

The Tool accounts for emissions from the following sources, as required by the Global Protocol's BASIC level of reporting:

- Stationary energy use from residents, businesses and off-road equipment
- On-road private and public transportation and rail transportation
- Solid waste and wastewater disposal and treatment

As part of this process, DNV GL and MAPC assessed the possibility of including emissions from product use, industrial processes, and land-use. Due to the limited data availability for these activities, they were not included. Table 1 summarizes the sectors, sub-sectors, emissions sources and energy types included in the Tool.

SECTORS, SUB-SECTORS, EMISSIONS SOURCES AND ENERGY TYPES INCLUDED IN THE TOOL

Sector	Sub-sector	Emissions sources	Energy types
Stationary Energy	Residential Buildings	Energy use in residential buildings as well as losses from distribution systems	Electricity Natural gas Heating Fuel Oil Petroleum Products
	Commercial and & Institutional Buildings & Manufacturing Industries	Energy use in commercial, government, industrial and institutional buildings as well as losses from distribution systems	
	Construction	Energy use associated with construction activities	
	Energy Industries*	Stationary combustion of fuel in various equipment, such as boilers and generators.	Various – may include natural gas, propane, and diesel

[16] The Global Covenant of Mayor's for Climate and Energy is the new designation for the Compact of Mayors. The Compact of Mayors was launched by UN Secretary, C40 Cities Climate Leadership Group (C40), ICLEI – Local Governments for Sustainability (ICLEI) and the United Cities and Local Governments (UCLG) –with support from UN-Habitat, the UN's lead agency on urban issues.

Transportation	Transportation	All on-road vehicles Railways Off-road vehicles/equipment	Gasoline Diesel CNG Electricity
Waste	Solid Waste	Landfills Incineration of waste generated in the community	Landfill gas (methane)
	Wastewater	Process and fugitive emissions from treating wastewater	Not applicable

*Note: Reporting of Energy Industries emissions is not required under GPC BASIC reporting requirements. For this reason, Energy Industries emissions are included for informational purposes only

GEOGRAPHIC BOUNDARY

For the Tool, the administrative boundary for each community has been chosen as the geographic boundary for inventory purposes. Establishing this geographic boundary does not exclude emissions related to community activities that occur outside the community geographic limits (e.g. electricity generation or landfilled waste emissions).

INVENTORY YEAR

Peabody used V4.2 of the Tool to develop the City's inventory. V4.2 of the Tool is set up to quantify GHG emissions for an inventory year of 2017, based on the availability of public data sets. The Tool identifies the additional data sets that will need to be updated to quantify GHG emissions for a year other than 2017.

QUANTIFYING GREENHOUSE GAS EMISSIONS

All emissions in this inventory are quantified using activity-based methodologies, which calculate emissions using activity data from each sector and emission factors. To calculate emissions accordingly, the basic equation is:

Activity Data (units) x Emission Factor (MT of GHG / unit) = Emissions (MT GHG).

Activity data refer to the relevant measurement of energy use or other GHG-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Known emission factors are used to convert energy usage or other activity data into associated quantities of GHG emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g., metric tons of CO2 per kWh of electricity).

Stationary Energy – Electricity

DATA SUMMARY

Grid-supplied electricity is provided throughout each community and powers the residential, commercial, and industrial sectors, in addition to community infrastructure and many transport systems. Electricity consumption data were provided by the Peabody Municipal Light Plant.

The Global Protocol also requires accounting of losses from transmission and distribution systems. A Massachusetts-specific electricity transmission and distribution grid loss factor of 5.13% (for the

year 2017) was calculated using guidance from the U.S. Energy Information Administration. The loss factor was determined by dividing the state's estimated losses by the result of total disposition minus direct use. Direct use electricity is the electricity generated mainly at non-utility facilities and that is not put onto the electricity transmission and distribution grid, and therefore direct use electricity does not contribute to transmission and distribution losses. This data is provided by EIA in their state electricity profile for Massachusetts within Table 10: Supply and Disposition of Electricity.

For municipally-owned buildings and facilities, electricity consumption data were provided by the City of Peabody.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

In accordance with Section 6.5 of the Global Protocol, the market-based approach for determining electricity emission factors was used in the Tool. The Global Protocol allows communities to use either a location-based or market-based approach to calculate emissions from grid-supplied electricity. The Tool includes default annual emissions factors for 2017 from MassDEP's GHG emissions reporting summaries.[17] Per guidance from DEP, and in accordance with the State's GHG inventory, the "Massachusetts-based approach" non-biogenic electricity emissions factor was used as the base assumption. CO2, CH4 and N2O electricity emission factors are provided in the DEP data.

Once the state-level default emission factor is determined, the Tool enables utility-specific adjustments to the electricity emission factors based on that utility's percent of total electricity sales reported to the DEP as non-emitting. Some utilities voluntarily report the percent of electricity sales from non-emitting resources to the DEP. If a utility voluntarily reports this information to the DEP, it is used as an input in the Tool to adjust the default State electricity emissions factor accordingly. If a utility does not voluntarily report this information to the DEP, the State average percent of electricity sales from non-emitting resources is used as a default in the Tool.

Reported emissions from all grid-supplied electricity consumed within the community boundary are reported as Scope 2 emissions. BASIC/BASIC+ reporting avoids double counting by excluding Scope 1 emissions from electricity generation supplied to the grid.

Communities with municipal aggregation programs have multiple electricity emission factors depending on the specific service offering (e.g., 5% Class I RECs, 50% Class I RECs, 100% Class I RECs). If a community has a municipal aggregation program, this data on the percent of Class I RECs by service offering is also used as an input in the Tool to adjust the default State electricity emissions factor.

Stationary Energy – Natural Gas

DATA SUMMARY

[17] MassDEP. "Draft 2017 Greenhouse Gas (GHG) Emission Factors to be used by Retail Sellers of Electricity Reporting under 310 CMR 7.71(9) 'Reporting Requirements for Retail Sellers of Electricity." 2019. https://www.mass.gov/files/documents/2019/05/30/rsef17-tsd.pdf

Grid-supplied natural gas is provided throughout most cities in Massachusetts and is primarily used by the residential, commercial, and industrial sectors for heat and hot water production. Natural gas is provided to communities either by an investor- owned utility (IOU) or through a municipal utility.

A majority of Massachusetts communities served by IOUs have access to aggregated community-wide natural gas consumption data through the MassSaveData website. For this reason, MassSaveData was used as the source for natural gas consumption data for most cities in the Tool. Natural gas consumption data from MassSave is broken out into two sectors – Residential and Commercial & Industrial.

The Global Protocol also requires accounting of losses from distribution systems. Based on an assessment of several studies that have been done on the subject of gas leakage from the distribution system network in and around the Boston, the Tool uses an average leakage rate of 2.7%. According to the Harvard study in the Boston area, 2.7%[18] is the average fractional loss rate of natural gas to the atmosphere from all downstream components of the natural gas system, including transmission, distribution, and end use.

For municipally-owned buildings and facilities, natural gas consumption data were provided by the City of Peabody.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

In accordance with Section 6.3 of the Global Protocol, real consumption data for each fuel type, disaggregated by sector was used for the inventory. Reported emissions from the usage of natural gas within the community's boundaries were reported as Scope 1 emissions. A universal emission factor provided by The Climate Registry was used to calculate natural gas emissions.[19]

TABLE A1: NATURAL GAS COMBUSTION EMISSIONS RATE

Type of Emission	CO2 Emission Factor (kg CO2 / MMBtu)	CO2 Emission Factor (MT CO2 / Therm)	Source
Natural Gas Consumption	53.06	0.0053	TCR

*Note CH4 or N2O are not included because these emissions are considered to be de minimis

Methane (CH4) emissions associated with distribution system leakage is also accounted for in the Tool. The total CO2 equivalent (CO2e) emissions factor for fugitive emissions from natural gas leakage was determined based on:

- Volume of natural gas per heat energy (m3 gas/therm gas)

[18] McKain, Et al., 2014. "Methane emissions form natural gas infrastructure and use in the urban region of Boston, Massachusetts." https://www.pnas.org/content/pnas/112/7/1941.full.pdf

[19] 2015 Climate Registry Default Emissions Factors, released April 2015

- A density value of natural gas of 0.7 kg/m3 based on values provided in the GHG Protocol stationary combustion tool
- The IPCC Tier 1 default for the mass fraction of methane in delivered natural gas (93.4%)
- A carbon dioxide content of 1.0% in the delivered natural gas

The overall emissions factor was then calculated to be 0.0518 MT CO2e/leaked therm.

Stationary Energy – Fuel Oil

DATA SUMMARY

Residential Buildings

For the Tool, residential oil usage data was based on the number of housing units in each community by type from the 2017 American Community Survey (ACS), and a percentage of units determined to be heated with fuel oil from the 2017 ACS. The property types identified were:

- Single-Family, Detached
- Single-Family, Attached
- Multi-Family, 2-4 Units
- Multi-Family, 5+ Units
- Mobile Homes

The average residential site fuel oil consumption by property type in Massachusetts was estimated using data from the U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS) on the average fuel oil consumption by property type and percent of total housing units by residential building type in the U.S., the number of housing units in Massachusetts by property type in Massachusetts, and the average fuel oil consumption averaged across all residential building types in Massachusetts. National-level and state-level data was used in places where community- level data was not available. This combination of national-level, state-level and community-level data was used to estimated annual fuel oil consumption by property type in the community.

Commercial Buildings

For the Commercial sector, fuel oil use estimates were based on the total number of employees and total number establishments by Primary Building Activity (PBA) in each community and the average expected energy use per employee in the Northeast region. The Executive Office of Labor and Workforce Development (EOWLD) ES-202 Employment and Wages Survey lists the number of employees and establishments by industry for each community, sorted by North American Industry Classification System (NAICS) codes.[20] The EIA 2012 Commercial Building Energy Survey (CBECS) analyzes energy use and consumption data per employee in the northeast based on Primary Building Activity (PBA). Table A2 below (generated by EIA) correlates the PBA codes used in CBECS with standard three-digit NAICS codes.

[20] Executive Office of Labor and Workforce Development. "EOWLD ES-292 Employment and Wages Survey" http://lmi2.detma.org/lmi/ lmi_es_a.asp

TABLE A2: COMMERCIAL PRIMARY BUILDING ACTIVITY (PBA) NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM (NAICS) CODES

PBA	NAICS Code (3-digit)
Education	611
Food Sales	445
Food Service	722
Inpatient Health Care	622
Lodging	623,721
Office	454, 481, 511, 516, 517, 518, 519, 521, 522, 523, 524, 525, 531, 533, 541, 551, 561, 624, 921, 923, 924, 925, 926, 928
Other	562, 927
Outpatient Health Care	621
Public Assembly	482, 485, 487, 512, 515, 711, 712, 713
Public Order/ Safety	922
Religious Worship	813
Retail (Mall)	446, 448
Retail (Non-mall)	441, 442, 443, 444, 451, 452, 453, 532
Service	447, 483, 484, 488, 491, 492, 811, 812
Warehouse/Storage	423, 424, 493

Fuel oil consumption by building type was not available for all PBAs but natural gas use for all PBAs was available. For these building types, a comparison between average fuel oil use to average natural gas use in the same building types was used, using Office buildings as a baseline. So, for example, if a specific PBA that uses natural gas uses 50% more natural gas than an Office building using natural gas, the analysis assumes that if the same PBA used fuel oil, it would use 50% more fuel oil than an Office building. This is the preferred method, as it yields a more conservative estimate.

Industrial Buildings

For the industrial sector, data was collected similarly to commercial data. Fuel oil use estimates were based on the total number of employees and total number of establishments by PBA in each community and the average expected energy use per employee in the Northeast region. The EOWLD ES-202 Employment and Wages Survey lists the number of employees and establishments by industry for each community, sorted by NAICS codes.[21] The EIA 2014 Manufacturing Energy Consumption Survey (MECS) analyzes energy use and consumption data based on PBA. Table A3 below (generated by EIA) correlates the PBA codes used in MECS with

[21] Executive Office of Labor and Workforce Development. "EOWLD ES-292 Employment and Wages Survey" http://lmi2.detma.org/lmi/ lmi_es_a.asp

standard three-digit NAICS codes. Industrial energy uses between 100 and 200 (such as power generation and utility operations) were not incorporated in this methodology.

TABLE A3: INDUSTRIAL NAICS CODES

PBA	NAICS Code (3-digit)
Apparel	315
Beverage and Tobacco Products	312
Chemicals	325
Computer and Electronic Products	334
Electrical Equip., Appliances, and Components	335
Fabricated Metal Products	332
Food	311
Furniture and Related Products	337
Leather and Allied Products	316
Machinery	333
Miscellaneous	339
Nonmetallic Mineral Products	327
Paper	322
Petroleum and Coal Products	324
Plastics and Rubber Products	326
Primary Metals	331
Printing and Related Support	323
Textile Mills	313
Textile Product Mills	314
Transportation Equipment	336
Wood Products	321

For municipally-owned buildings and facilities, natural gas consumption data were provided by the City of Peabody. Fuel oil is manually entered into MEI on an annual basis for Green Communities reporting. For those communities not participating in the Green Communities program, municipal government will have to work with internal departments or heating oil companies to determine the total fuel oil consumption associated with municipally-owned buildings and facilities in a given calendar year.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

In accordance with Section 6.3 of the Global Protocol, and as detailed above, a collection of representative consumption surveys, modelled energy consumption, and regional and national fuel

consumption data was used to properly characterize fuel oil consumption in each community within the Tool. Reported emissions from the usage of fuel oil within each community's boundaries were reported as Scope 1 emissions. Universal emission factors provided by the U.S. Environmental Protection Agency (EPA) was used to calculate fuel oil emissions.

TABLE A4: FUEL OIL COMBUSTION EMISSIONS RATES

Type of Emission	CO2 Emission Factor (MT CO2 / MMBtu)	CH4 Emissions Factor (MT CH4 / MMBtu)	N2O Emissions Factor (MT N2O / MMBtu)	Source
Fuel Oil Combustion (Distillate Fuel Oil #2)	0.07396	0.000003	0.0000006	EPA

Stationary Energy – Off-Road Vehicles and Equipment

DATA SUMMARY

The off-road data is derived from a publicly available U.S. EPA emission modeling system called the Motor Vehicle Emission Simulator (MOVES). MOVES estimates emissions for mobile non-road sources at the national and county level for criteria air pollutants, greenhouse gases, and air toxics. The Tool is designed to take county-level off-road emissions data for each county and apportion it to individual communities based on a proportionality multiplier.

The MOVES2014b modeling tool multiplies equipment population, average load factor expressed as an average fraction of available power, available power in horsepower, hours of use per year, and emission factors with deterioration and/or new standards. Emissions are then temporally and geographically allocated using appropriate allocation factors. This produces emissions estimates attributable to many non-road activities but does not include aircraft, commercial marine vessels, or rail, which are the primary non-road transportation sources contributing to GHG emissions.

Table A5 summarizes the methodologies used for each of the off-road emission sources.

TABLE A5: OFF-ROAD EMISSIONS SOURCES AND METHODOLOGIES

Off-Road Mobile Emission Source	Proportionality Multiplier Source	Category
Industrial Equipment	Manufacturing Jobs	Manufacturing Industries
Lawn and Garden Equipment	Square Feet of Developed Open Space	Comm. & Inst. Buildings
Light Commercial Equipment	Total Jobs Excluding Manufacturing Jobs	Comm. & Inst. Buildings
Construction Equipment	Square Feet of Commercial Development Under Construction	Construction

Data on manufacturing employment and total employment at both the community and county level is derived from the U.S. Census. MAPC generated a supporting dataset on square feet of developed open space by municipality and county from the 2016 Land Cover / Land Use data set produced by MassGIS. Aggregated data from CoStar was used to determine square feet of commercial development under construction by municipality and county.

GPC QUANTIFICATION METHOD USED

In accordance with Section 6.3 and 7.7 of the Global Protocol, the community-wide inventory used the modeling tool MOVES2014b data, disaggregated by sub-sector. Emissions factor modeling parameters in MOVES2014b were developed and used to produce emissions factors and the emissions outputs were restricted to county-level geographic bounds, the smallest subdivision possible in the model.

Stationary Energy – Energy Industries

DATA SUMMARY

Data on emissions generation by the energy industry for each community was provided by the EPA's Greenhouse Gas Reporting Program (GHGRP). All facilities included in the database, excluding landfills that do not generate electricity, are included in the Tool. These facilities are required to report biogenic CO2 emissions and CO2 emissions excluding biogenic CO2 separately.

For co-generation power plants, if the electricity generated from these facilities is consumed directly within the community (e.g. co-generation facility at large business or university), the emissions from this power plant should be captured under BASIC/BASIC+ GPC reporting guidelines. The natural gas consumption and associated emissions required to generate electricity at these power plants is captured in the utility data used to calculate emissions from the Stationary Energy: Buildings sector and included in the total reported emissions. Therefore, the EPA data on emissions associated with each co- generation facility is provided for informational purposes only.

For traditional power plants without co-generation, all electricity produced is sent directly to the regional electrical grid. This energy is part of the regional electricity mix and consumed by all communities that use electricity from the regional grid.

For this reason, the direct emissions from these power plants should not be captured under BASIC/BASIC+ GPC reporting guidelines. In other words, the emissions from these power plants are dispersed across the region instead of solely being attributed to the community in which the power plant is physically located. The emissions are captured in the Tool as part of the regional electricity emission factor that influences Scope 2 emissions from electricity consumption associated with the regional grid.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

For the reasons stated in the data summary above, emissions from this subsector are not quantified to avoid double counting.

Transportation – On-road Passenger and Commercial Vehicles

DATA SUMMARY

At the time of releasing the Tool, 2014 was the most recent year of complete and accurate data available from the Massachusetts Registry of Motor Vehicles as they transition to a new system for storing their data. Communities should use more recent years as they become available in the future.

The private on-road vehicle data is derived from the Massachusetts Vehicle Census (MAVC)[22], which is a catalog of information about vehicles registered in the Commonwealth from 2009 to 2014 developed by MAPC. The MAVC combines information from vehicle registrations, inspection records, mileage ratings, and other sources to document the ownership and mileage history of each vehicle (Massachusetts Vehicle Census v.3, 2009 – 2014 Technical Documentation October 10, 2016).

In the context of the Tool, the MAVC provides counts of the number of vehicles garaged in each municipality broken out by passenger and commercial vehicles and by fuel type. Fuel types included gasoline, diesel, flex fuel, hybrid, and electric. In addition to counts, the MAVC provides average vehicle miles travelled (VMT) and average fuel efficiency of vehicles. The MAVC data for 2009 to 2014 include commercial vehicle fleets and rental cars but do not include municipally-operated vehicles, such as police cars or school buses.

TABLE A6: DETAILED ATTRIBUTES REPORTED FOR ON-ROAD VEHICLES GARAGED IN MASSACHUSETTS

Attribute	Details
Count	Total vehicles, based on the municipality where the vehicle is garaged. For the Inventory Tool, counts are tabulated by vehicle type (non-commercial passenger vehicles and commercial vehicles) and by fuel type (gasoline, diesel, flex fuel, hybrid, and electric).
Count of Vehicles with Valid Mileage Estimate and Fuel Economy Rating	Total vehicles that have a valid mileage estimate and drive less than 200 miles per day, based on the municipality where the vehicle is garaged, and have a valid fuel economy rating. As with the overall count, counts for vehicles with a valid mileage estimate and fuel economy rating are tabulated by vehicle type (non-commercial passenger vehicles and commercial vehicles) and by fuel type (gasoline, diesel, flex fuel, hybrid, and electric).
Average Daily Vehicle Miles Travelled (DVMT) by Fuel Type	Average daily mileage for vehicles with a valid mileage estimate and fuel economy rating. Calculated by vehicle type (non-commercial passenger vehicles and commercial vehicles) and by fuel type (gasoline, diesel, flex fuel, hybrid, and electric).
Average Fuel Economy Rating (mpg) by Fuel Type	Average fuel economy rating for vehicles with valid mileage estimates, weighted by average daily mileage. Calculated as total estimated fuel consumption (gallons/day) for vehicles with valid mileage estimates and fuel economy ratings, divided by total daily miles for same vehicles. Calculated by vehicle type (non-commercial passenger vehicles and commercial vehicles) and by fuel type (gasoline, diesel, flex fuel, hybrid, and electric).

22 https://www.mapc.org/learn/data/#vehiclecensus

TABLE A7: VEHICLE DATA COLLECTED FROM MASSENERGYINSIGHT

Type and Use	Unit
Municipal Vehicle Fleet Gasoline	Gallons
Municipal Vehicle Fleet Diesel	Gallons

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

In accordance with Section 7.3 of the Global Protocol, the resident activity method was used to quantify on-road transportation emissions. This method quantifies emissions from transportation activity undertaken by community residents and businesses that garage their vehicles in the community.

Universal emission factors were used to calculate gasoline and diesel emissions. Because electric vehicles registered in one community may charge in multiple communities, the average electricity emission factor of Eversource & NGRID was used to approximate emissions associated with charging electric vehicles.

TABLE A8: PRIVATE ON-ROAD VEHICLES EMISSIONS FACTORS

Fuel Type	Emission Factor	Emission Factor Units	Source
Gasoline	0.00878	MT CO2e / gallon	TCR
Diesel	0.01021	MT CO2e / gallon	TCR
Electricity	0.000225813	MT CO2 / kWh	Eversource & NGRID Average

Transportation – Public On-road and Rail-based Transportation

DATA SUMMARY

Public transportation, consisting of buses, rapid transit, and commuter rail, spans the on-road and rail-based transportation subsectors. For on-road and rail-based public transportation in Greater Boston, the Tool uses consumption and route data provided by the MBTA. At the time of publishing for the Tool, the MBTA only had access to system-wide fuel and electricity consumption data. MAPC, therefore, developed a method to allocate system-wide totals to individual municipalities using route length and route frequency. The specifics of the calculations MAPC used to produce the supporting MBTA data set used in the Tool are provided in the supporting technical documentation for the Tool.[23] The calculations produce an estimated number of annual vehicle miles travelled that is based on the length and frequency of routes that take place within the geographic boundary of

[23] http://www.mapc.org/wp-content/uploads/2020/03/04102020_MAPC-Step-by-Step-GHG-Inventory-Guide.pdf

the inventory. These annual vehicle miles travelled are used to portion out the system-wide fuel and electricity consumption data to each respective municipality.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

Trackless trolley and bus emissions were calculated in accordance with Section 7.3 of the GPC. Heavy rail, light rail, and commuter rail emissions were quantified in accordance with Section 7.4 of the GPC.

Universal emission factors provided by The Climate Registry were used to calculate gasoline and diesel emissions. Because electricity used in public transportation spans across multiple communities, the average electricity emission factor of Eversource & NGRID was used to approximate emissions associated with electricity consumption in public transportation vehicle.

TABLE A9: PUBLIC TRANSIT EMISSIONS FACTORS

Fuel Type	Emission Factor	Emission Factor Units	Source
Diesel	0.01021	MT CO2e / gallon	TCR
CNG	0.05294	MT CO2e / MMBTU	TCR
Electricity	0.000225813	MT CO2 / kWh	Eversource & NGRID Average

Waste – Solid Waste Disposal & Incineration

DATA SUMMARY

For most communities in Massachusetts, solid waste is collected through a combination of a municipal curbside-pick up and private waste haulers. To calculate the emissions associated with solid waste, information is needed on the amount of solid waste collected from residents and businesses as part of the curbside pickup, as well as the amount of solid waste collected by private haulers. Information on where the MSW is disposed of (landfill or incineration facility) is also needed. Waste data for Peabody were provided by the City of Peabody and by the Massachusetts Department of Environmental Protection's Recycling & Solid Waste Data for Massachusetts Cities & Towns.[24]

The amount of methane generated by landfilled waste is highly dependent on the amount of degradable organic carbon in the landfilled waste. To determine the amount of organic carbon in landfilled waste, communities can provide data from a community-specific waste characterization study. If community does not have this information, the Tool assumes the State- level waste composition based on data from MA DEP's Summary of Waste Combustor Class II Recycling Program Waste Characterization Studies. The waste subcategories from the Massachusetts waste composition study (e.g. "Waxed Cardboard") were mapped to the GPC waste categories (e.g. "Paper") in order to use the appropriate Global Protocol equations to calculate emissions from

[24] https://www.mass.gov/lists/recycling-solid-waste-data-for-massachusetts-cities-towns

landfilled and incinerated waste. See Table A10 below for default State waste composition data and the corresponding Global Protocol categories.

TABLE A10: OVERALL MASSACHUSETTS WASTE COMPOSITION BY DETAILED MATERIAL CATEGORY MAPPED TO GLOBAL

Protocol Waste Categories Waste Category/Sub-category	Weighted Average	Global Protocol Waste Category
Paper		
Uncoated Corrugated Cardboard/Kraft Paper	9.2%	Paper
Waxed Cardboard	0.3%	Paper
High Grade Office Paper	0.5%	Paper
Magazines/Catalogs	0.8%	Paper
Newsprint	0.7%	Paper
Other Recyclable Paper	3.6%	Paper
Compostable Paper	5.8%	Paper
Remainder/Composite Paper	0.7%	Paper
Plastic		
PET Beverage Containers (non-MA deposit containers)	0.7%	Other
PET Containers other than Beverage Containers	0.2%	Other
Plastic MA Deposit Beverage Containers	0.1%	Other
HDPE Bottles, colored and natural	0.4%	Other
Plastic Tubs and lids (HDPE, PP, etc.)	0.4%	Other
Plastic Containers #3-#7 (which originally contained non-hazardous material)	0.5%	Other
Expanded Polystyrene Food Grade	0.4%	Other
Expanded Polystyrene Non-food Grade	0.2%	Other
Bulk Rigid Plastic Items	1.6%	Other
Film (non-bag clean commercial and industrial packaging film)	0.5%	Other
Grocery and other Merchandise Bags	0.5%	Other
Other Film means plastic film	4.9%	Other
Remainder/Composite Plastic	2.8%	Other
Metal		
Aluminum Beverage Containers (non-MA deposit containers)	0.0%	Other
Aluminum MA Deposit Beverage Containers	0.1%	Other
Tin/Steel Containers	0.6%	Other
Other Aluminum	0.3%	Other

Other Ferrous and non-ferrous	0.8%	Other
White Goods	0.2%	Other
Remainder/Composite Metal	1.6%	Other
Glass		
Glass Beverage Containers (non-MA deposit containers)	0.5%	Other
Other Glass Packaging Containers (non-MA deposit containers)	0.3%	Other
Glass MA Deposit Beverage Containers	0.3%	Other
Remainder/Composite Glass	0.4%	Other
Organic Materials		
Food Waste	26.0%	Food
Branches and Stumps	0.1%	Garden Waste and Plant Debris
Prunings, Trimmings, Leaves and Grass	2.5%	Garden Waste and Plant Debris
Manures	0.1%	Garden Waste and Plant Debris
Remainder/Composite Organic	2.6%	Garden Waste and Plant Debris
Construction and Demolition (in the MSW stream)		
Asphalt Pavement, Brick, and Concrete	0.1%	Other
Aggregates, Stone, Rock	0.4%	Other
Wood – Treated	5.7%	Wood
Wood – Untreated	2.0%	Wood
Asphalt Roofing	0.3%	Other
Drywall/Gypsum Board	0.6%	Other
Carpet and Carpet Padding	3.3%	Other
Remainder/Composite Construction and Demolition	2.6%	Other
Household Hazardous Waste		
Ballasts, CFLs, and Other Fluorescents	0.0%	Other
Batteries – Lead Acid	0.0%	Other
Batteries – Other	0.0%	Other
Paint	0.1%	Other
Bio-Hazardous	3.3%	Other
Vehicle and Equipment Fluids	0.1%	Other
Empty Metal, Glass, and Plastic Containers	0.1%	Other
Other Hazardous or Household Hazardous Waste	0.2%	Other

Electronics		
Computer-related Electronics	0.2%	Other
Other "brown goods"	0.7%	Other
Televisions and Computer Monitors	0.2%	Other
Other Materials		
Tires and other rubber	0.7%	Other
Textiles	5.8%	Textiles
Bulky Materials	0.9%	Other
Mattresses	0.1%	Other
Restaurant Fats, Oils and Grease	0.1%	Food
Other Miscellaneous	1.0%	Other
Total	100%	

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

Landfilled Waste

Solid waste sent to landfills produces methane (CH_4). For waste sent to landfills, methane emissions were calculated using Global Protocol Equations 8.1, Equation 8.3, and Equation 8.4.

- Equation 8.1 is used to calculate the total degradable organic carbon (DOC) in the landfilled waste based on the fraction of landfilled waste that is food, garden waste and other plant debris, paper, wood, textiles, and industrial waste.
- Equation 8.4 uses the DOC estimate derived from Equation 8.1 to calculate the overall methane generation potential of the waste sent to landfill. Equation 8.4 assumes a methane correction factor of 1.0 because landfills in Massachusetts are actively managed, assumes a default GPC input of 0.6 for the fraction of degradable organic carbon degraded variable, assumes a default GPC input of 0.5 for the fraction of methane in landfill gas, and uses the DOC variable calculated in Equation 8.1.
- GPC Equation 8.3 uses the total mass of waste sent to landfill, the methane generation potential of the waste calculated in GPC Equation 8.3, a GPC default fraction of methane recovered at landfills of 0 and a default oxidation factor of 0.1 because landfills in Massachusetts are actively managed. The methane generation potential of waste sent to landfill calculated by GPC Equation 8.4 is used to calculate the overall methane commitment for solid waste sent to landfill in GPC Equation 8.3.

Incinerated Waste

Solid waste that is incinerated produces methane (CH4), nitrous oxide (N2O) and carbon dioxide (CO2). GHG emissions from incineration of municipal solid waste are calculated using Global Protocol Equation 8.6, Equation 8.7, and Equation 8.8. Emissions generated as a result of incineration out of community boundaries is considered Scope 3 emissions.

- Equation 8.8 is used to calculate the N2O emissions from waste incineration using the mass of waste incinerated, the percent of waste in each organic material category, and the default N2O emission factor for municipal solid waste from Global Protocol Table 8.6.
- Equation 8.7 is used to calculate the CH4 emissions from waste incineration using the mass of waste incinerated, the percent of waste in each organic material category, and the default CH4 emission factor for continuous incineration: stoker from Global Protocol Table 8.5.
- Equation 8.6 is used to calculate the non-biogenic CO2 emissions from waste incineration using the mass of waste incinerated, the percent of waste in each organic material category, and the default values from Global Protocol Table 8.4 on dry matter content by material type, fraction of fossil fuel carbon in each material type, and oxidation factor.

The emissions factors associated with solid waste disposal and incineration are embedded in the assumptions in the Global Protocol equations used to calculate emissions from landfilled waste (Equations 8.1, 8.2 and 8.4) and the Global Protocol equations used to calculate emissions from incinerated waste (Equations 8.6, 8.7 and 8.8). See Global Protocol Quantification Method Used section directly above for explanations on assumptions used in those equations.

Waste – Biological Treatment

DATA SUMMARY

To calculate the emissions associated with biological treatment, information is needed on the amount of separated organic waste collected in the community from residents and businesses as part of the curbside pickup, as well as the amount of separated organic waste collected by private haulers. Information on where the separated organic waste is disposed of (compositing facility or anaerobic digestion facility) is also needed. Data on the total weight of separated organic waste collected that is destined for composting or anaerobic digestion must be provided by individual municipal waste collection programs and individual private haulers.

If a community knows the percent of their collected separated organic material that is sent to a composting facility versus an anaerobic digestion facility, they can enter that data into the Tool. If a community does not have this information, the Tool assumes the State-level percent of disposed separated organic material sent to composting (50.0%) and anaerobic digestion (50.0%).

For the City's 2017 inventory, the City of Peabody sent 3,359 tons of waste to compost.

GPC QUANTIFICATION METHOD USED

Compositing of separated organic material produces nitrous oxide (N2O) and methane (CH4), while anaerobic digestion of separated organic material produces only methane (CH4). Global Protocol Equation 8.5 is used to calculate emissions from both composting and anaerobic digestion and uses the mass of organic waste treated by each treatment type, the default CH4 emission factor from Global Protocol Table 8.3 based on treatment type, the default N2O emission factor from Global Protocol Table 8.3 based on treatment type, and the estimated percentage of CH4 that is recovered at each facility. Compositing facilities in Massachusetts do not have CH4 recovery, while anaerobic digestion facilities have 100% CH4 recovery.

The emissions factors associated with biological treatment of separated organic material are embedded in the assumptions in the Global Protocol Equation 8.5 used to calculate emissions from compositing and anaerobic digestion facilities. See Global Protocol Quantification Method Used section directly above for explanations on assumptions used in those equations.

Waste – Wastewater

DATA SUMMARY

Data used to estimate wastewater emissions in communities served by the Massachusetts Water Resources Authority (MWRA) uses a combination of default values from the EPA and the GPC and data on methane recovery rates at MWRA facilities. Data used to estimate wastewater emissions in communities not served by the MWRA uses data from the Massachusetts Department of Environmental Protection (DEP) "Statewide Greenhouse gas Emissions Level: 1990 Baseline and 2020 Business as Usual Projection Update" report.

GLOBAL PROTOCOL QUANTIFICATION METHOD USED

Indirect nitrous oxide (N2O) emissions from wastewater effluent and CH4 generation emissions from wastewater treatment were calculated using the methodology outlined in the Massachusetts Department of Environmental Protection (DEP) "Statewide Greenhouse gas Emissions Level: 1990 Baseline and 2020 Business as Usual Projection Update" report. This methodology is in compliance with methodologies recommended by the Global Protocol. Communities that are not served by an MWRA wastewater treatment plant do have some methane emissions associated with wastewater treatment because methane capture and co-generation systems are not in place.

The Massachusetts DEP equation for calculating methane (CH4) emissions includes the total population served by the wastewater treatment plant, total statewide CH4 emissions from municipal wastewater treatment, and the total State population not served by MWRA. The general approach is to use that State's data on total methane emissions from wastewater treatment (13,706 MT CH4/year) and the total State population not served by MWRA (4,279,130 people) to determine a per capita wastewater treatment methane emissions factor (0.003203 CH4/year/capita) that can be used by all Massachusetts cities not served by MWRA to estimate CH4 emissions from wastewater treatment.

The Massachusetts DEP equation for calculating nitrous oxide (N2O) emissions includes the total population served by the wastewater treatment plant, total statewide N2O emissions from municipal wastewater treatment, and the total State population not served by MWRA. The general approach is to use that State's data on total nitrous oxide emissions from wastewater treatment (308.4 MT N2O /year) and the total State population not served by MWRA (4,279,130 people) to determine a per capita wastewater treatment methane emissions factor (0.000072 N2O /year/capita) that can be used by all Massachusetts cities not served by MWRA to estimate N2O emissions from wastewater treatment.

For the portion of the population served by an MWRA wastewater treatment plant (Clinton, Deer Island, Greater Lawrence, Pittsfield, Rockland) indirect nitrous oxide emissions from wastewater effluent were calculated using GPC Equation 8.11. For these MWRA facilities, no methane is released from the treatment process. Methane is captured and diverted to co-generation systems where it is used to heat buildings and generate electricity via steam turbine generators. Equation

8.11 include the total community population served by the wastewater treatment plant, the annual per capita protein consumption provided by the EPA, and the default Global Protocol factors for adjustment of non-consumed protein, fraction of nitrogen in protein, factor for industrial and commercial co-discharged protein into the sewer system, nitrogen removed from sludge, and emissions factor for N2O emissions from discharged wastewater. Emissions generated as a result of methane capture and co-generation occurring outside of a community's boundary are considered Scope 3 emissions.

According to the Global Protocol, wastewater used to generate energy is considered a stationary energy source. Stationary energy sources outside of each community's boundary are not included in the inventory.