Municipal Decarbonization Roadmap

West Tisbury

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DOER Massachusetts Department of Energy Resources

Green Communities Massachusetts Department of Energy Resources

ICF

Purpose and Acknowledgements

West Tisbury is committed to taking action to mitigate climate change. West Tisbury aims to lead by example and reduce emissions from facilities, equipment, and operations to support climate and sustainability goals and make operations more efficient. As a participant in the Massachusetts Green Communities program, West Tisbury has already begun to identify and implement strategies to reduce energy use and costs by implementing clean energy projects in municipal buildings, facilities, and schools. In 2022, the Martha's Vineyard Commission released a Climate Action Plan (CAP) in collaboration with the Town of West Tisbury, identifying the steps necessary to reduce greenhouse gas emissions from the town. The CAP addresses a much broader set of emission sources, than this roadmap, but offers key insights into the opportunities for decarbonization, as well as the overarching commitment of the town to take an environmentally sustainable approach to local governance. This Decarbonization Roadmap provides a framework for West Tisbury to further these efforts and continue implementing clean energy strategies to eliminate the use of fossil fuels on-site by 2040 in line with the communities goals as outlined in the 100% Renewable Initiative.

While West Tisbury's goal is to decarbonize municipal facilities by 2040, not all buildings and facilities are included in this roadmap. 97.0% of municipal emissions are covered by the buildings included in the roadmap, and buildings and facilities not included in the formal roadmap will be described at a high level at the end of the Municipal Emissions Baseline section, and recommended decarbonization efforts will be suggested in the Decarbonization Roadmap Narrative. For estimating the municipal emissions over time, these buildings and facilities will be assumed to uniformly reduce emissions over the twenty-eight years covered in the roadmap.

List of Contributors

The support for the production of this roadmap came from the DOER Green Communities Division.

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Executive Summary

This Decarbonization Roadmap[1] describes West Tisbury's municipal building portfolio and covers the various aspects of municipal emissions from building construction, operation, and maintenance as well as vehicle fleet emissions. The goal of this Roadmap is to identify Energy Conservation Measures (ECMs) to achieve complete fossil fuel elimination for municipal buildings and vehicles as well as reduce overall energy use intensity by the year 2040. This Roadmap considers how emissions are generated throughout West Tisbury's facilities and vehicles and the potential costs associated with the ECMs necessary to achieve decarbonization by the target year. West Tisbury's staff worked closely with their technical assistance team to identify the scope of the Roadmap, incorporate stakeholder feedback, develop the municipal goals, and identify implementation processes and roles to achieve the strategies outlined in the Roadmap.

Summary of West Tisbury

West Tisbury, Massachusetts, a small rural town on Martha's Vineyard, is actively pursuing ambitious energy efficiency and decarbonization goals. Guided by its Energy Committee, the town has committed to reducing fossil fuel use by 100% and increasing its share of renewable electricity by 2040. These local efforts align with broader initiatives under the Massachusetts 2025–2027 Energy Efficiency and Decarbonization Plan, which includes West Tisbury through its participation in the Cape Light Compact. The plan, approved by the Department of Public Utilities, outlines targeted investments in energy efficiency, electrification, and equitable access to clean energy solutions. Programs include incentives for heat pump installations, weatherization, and support for low-income households. West Tisbury benefits from these offerings, helping residents and businesses transition to cleaner energy while lowering utility costs. Appointed with Vineyard Power (a local renewable energy non-profit) as a Mass Save Community First Partner, West Tisbury is raising awareness of energy efficiency and decarbonization programs and incentives.

Summary of Municipal Building Portfolio

The Up-Island Regional School District (UIRSD), consisting of West Tisbury School, and the seven municipal facilities managed by West Tisbury are included in this roadmap. These facilities are a critical part of West Tisbury's operations and services and are directly utilized by the community, including the Up-Island RSD and West Tisbury School, community emergency services,

Facilities Included in Baseline Inventory
Town Hall
Library
Howes House
Fire Station
Public Safety Building
Highway - Public Safety Complex
West Tisbury School

[1] The decarbonization roadmap is distinct from a community's ERP in that it lays out the path to municipal decarbonization by 2040, while an ERP is designed to create a path to at least a 20% energy reduction. The roadmap focuses on electrification opportunities and EUI reduction strategies.

and the town building which serves as administrative space.

The West Tisbury Facilities Manager and Up-Island RSD will be the lead implementers of energy management strategies and programs impacting building operations and maintenance. The two primary departments work closely with the town's Facilities Manager, the UIRSD, Committee Selectboard, Capital Improvement Committee, Facilities & Maintenance Committee, and the Energy Committee to assess building needs, identify opportunities for clean energy improvements, and budget for or identify additional funding opportunities to implement facility and fleet upgrades.

Summary of Municipal Emissions

As shown in Table 1, West Tisbury's emissions profile is primarily comprised of buildings for the Municipality and the town's vehicle fleet.

Table 1. Summary of FY22 Metric Tons of CO2 equivalent emissions ($MTCO_2e$)

Emission Category	Emissions in Baseline Year ($MTCO_2e$)	Ownership
Buildings	343.8	Municipality
Open Space	-	Municipality
Vehicle	75.8	Municipality
Water and Sewer	-	Municipality
Street Lighting	0.7	Municipality
Total	**420.4**	

Source: MEI (2025) and West Tisbury (2025). Note that while UIRSD is included within the roadmap, the West Tisbury School is located within West Tisbury's MEI account not the UIRSD account, which is why no UIRSD emissions are presented in Table 1.

The recommendations laid out in this roadmap represent the next steps that the town of West Tisbury should consider on their path to net-zero emissions. While additional actions can be taken to further reduce emissions and energy consumption, this roadmap proposes a realistic approach to eliminating onsite fossil fuel usage while simultaneously reducing overall energy consumption through reasonable building management and system changes.

Summary of Emissions Reduction Potential

Based on the analysis detailed in this roadmap, the potential for West Tisbury to reduce their overall emissions to net-zero by 2040 follows a path of consistent work and incremental improvements over the coming 15 years. The work performed to convert lighting for most buildings to LED fixtures demonstrates a strong commitment to decarbonizing the town's facilities, and continuing those projects will be crucial to achieving the milestones set out in this roadmap. As shown in Table 2**Error! Reference source not found.**, West Tisbury will meet the onsite fossil fuel elimination by 2040 goal but also will adopt strategic EUI reduction projects at their facilities to exceed the recommended EUI reduction targets of 30% by 2040.

Table 2. Summary of Municipal Emissions Reductions

Targets	2022	2027	2030	2040	2050
Reduce emissions from onsite fossil fuels via electrification	0%	32%	85%	100%	100%
Zero emission vehicles (ZEVs) in light-duty fleet adoption (% of fleet)	0%	10%	25%	80%	100%
Zero emission vehicles (ZEVs) in medium-/heavy-duty fleet adoption (% of fleet)	0%	0%	10%	25%	100%
Energy Use Intensity reduction (deep energy retrofits/retro commissioning)	0%	25%	43%	49%	49%
Total Emissions Reduction Goals (% of 2022 emissions)	0%	28%	68%	90%	97%

West Tisbury has a long track record of participating in DOER's programs to achieve energy efficiency, reduction, and decarbonization. Over the coming 25 years, they commit to continuing that by working with their regional school district partners to transition West Tisbury School away from fossil fuels and pushing for more efficient building systems to mitigate overall energy consumption.

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Overview

Overview

The West Tisbury Municipal Decarbonization Roadmap includes six municipal and UIRSD facilities comprising 97.0% of municipal building emissions: The West Tisbury Town Hall, Library, Howes House, Fire Station #1, Public Safety Building (which included Fire Station #2 and the Police Department), and West Tisbury School.

The first step in developing this decarbonization roadmap was to assess the current greenhouse gas (GHG) emissions trends for the municipality's buildings. The baseline assessment provides a year-by-year view of GHG emissions. This section provides an overview of the methodology used to develop the emissions baseline, the municipal level emissions trends, and the facility level emissions for the baseline year of FY2022.

Data sources used to develop baseline building emissions and characteristics include MassEnergyInsight (MEI), and data provided by West Tisbury on each of the included facilities. The fuel consumption and emission baseline used for the West Tisbury buildings is obtained from MEI. Emission factors utilized by MEI are reported on the DOER Decarbonization Roadmap Guidance Document[2], and summarized in the technical appendix.

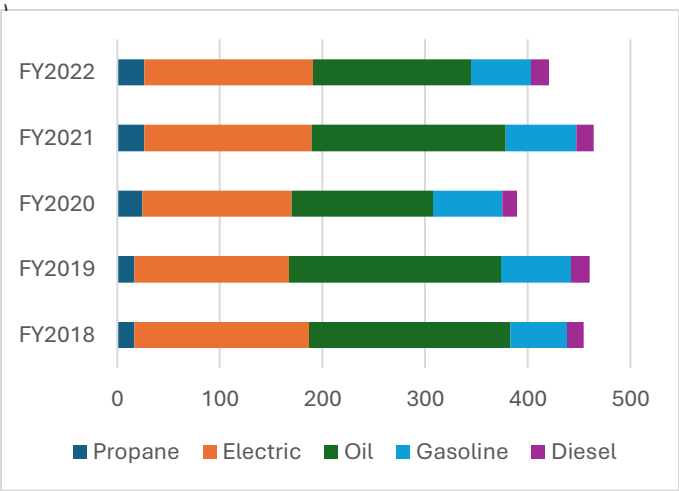
Municipal Baseline

Emissions Over Time

As shown in Figure 1, West Tisbury's municipal emissions have been steadily decreasing over time, with lower consumption of all on-site fossil fuels in FY22 since FY18. Decreases in emissions range from a 3% decrease in emissions from electricity to a 22% decrease in heating oil emissions. As a Green Community, West Tisbury has been continually engaging in ECMs and EUI reduction strategies.

During the baseline year of FY2022, West Tisbury's municipal emissions were comprised of 6% propane, 39% electricity, 14% gasoline, 4% diesel, and 37% oil.

Figure 1: West Tisbury Municipal Emissions (FY18 - FY22, $MTCO_2e$



Facility Specific Fuel Consumption and Emissions for the Baseline Year

This section lays out baseline fuel consumption at a facility level for each of the six municipal buildings included in the decarbonization roadmap. For each building, a brief narrative description of the building uses including regular and outlier cases, a brief overview of building characteristics[3], a summary of fuel usage by emissions in the baseline year (FY2022), and a summary of implemented ECMs.

[2] To compare decarbonization timelines between communities this roadmap uses the proposed statewide emission factors published in the DOER Decarbonization Roadmap guidance. The authors of this roadmap acknowledge that West Tisbury currently has much lower emission factors than the state average due to their solar array on the capped landfill. As a result, baseline emissions from West Tisbury's electrical usage at municipal facilities is lower than reported in this document.

[3] The building characteristics are categorized as poor, fair and good indicating the presence of significant deferred maintenance (poor), some deferred maintenance (fair), or no deferred maintenance, but aging equipment (good), or no deferred maintenance and no aging equipment (excellent)

Table 3 shows the summary of emissions at municipal facilities, street lighting, and vehicles by fuel type. The two largest sources of emissions in 2022 were the West Tisbury School and Vehicles. Decarbonizing HVAC and water heating equipment is a priority in the decarbonization roadmap.

Table 3. Summary of Municipal Emissions for FY2022 ($MTCO_2e$) by Facility and Fuel Type

Name	Electric	Natural Gas	Oil	Propane	Diesel	Gasoline	Fuel Use Total
Town Hall	13.12	0	0	5.77	0	0	**18.89**
Library	33.57	0	0	0	0	0	**33.57**
Howes House	6.8	0	0	3.35	0	0	**10.15**
Fire Station #1	4.03	0	0	5.94	0	0	**9.97**
Public Safety Building	22.72	0	11.68	0	0	0	**34.4**
Highway - Public Safety Complex	2.21	0	0	7.48	0	0	**9.69**
West Tisbury School	80.81	0	142.3	3.99	0	0	**227.1**
Open Space	0.04						**0.04**
Streetlights	0.74	0	0	0	0	0	**0.74**
Vehicle	0	0	0	0	17.52	58.3	**75.82**

Decarbonization Roadmap

Decarbonization Roadmap Narrative

West Tisbury's building portfolio presents multiple opportunities to implement decarbonization strategies and meet West Tisbury's decarbonization goals. The following section describes the key strategies that West Tisbury can implement at their facilities to eliminate onsite fossil fuel use by 2040 and make incremental emissions reductions beginning in the near term. While this Roadmap identifies building-specific strategies for West Tisbury to incorporate into capital and facility planning, it is also important for all building development, design, and maintenance activities to adhere to decarbonization principles to the extent possible. This may include the integration of efficiency and electrification measures into West Tisbury's planning and procurement processes and advancing building standards and equipment requirements in addition to the specific strategies described in this section.

This section provides a high-level overview and facility-specific recommendations of decarbonization strategies to be implemented by the community. These actions are presented in four distinct time categories (2027, 2030, 2040, and 2050) to capture and effectively distribute fiscal and technical capacity for the community. This framework also ensures that the decarbonization process aligns with existing equipment replacement where possible. The high-level summary provides an overview of the community's goals for actions in the near term (2027 and 2030), followed by their goals for the long term (2040 and 2050).

As West Tisbury is required to maintain emergency shelter functionality at its designated facilities, current technical electrification solutions do not exist where self-sufficiency can be consistently delivered for 72 hours. As electrification options such as batteries, distributed energy projects, and other technologies come onto the market and are financially feasible, West Tisbury will adopt them and add that transition to their decarbonization roadmap. West Tisbury has plans to implement an Energy Storage System (ESS) at the library in early 2026. The library serves as a cooling and heating shelter , and public water source during extended power outages. As feasible, West Tisbury will continue to implement additional ESS to their facilities to increase resilience and reliability.

Implementation Areas

This roadmap breaks down implementation into six main categories: Lighting Retrofits, Weatherization Measures, Envelope/Insulation Improvements, HVAC Electrification and Controls Retrofit, Water Heating Electrification, and Solar PV Installation. These comprise most projects that facilities can implement to either reduce their EUI or transition away from fossil fuel usage. This roadmap characterizes those six types with the following definitions.

Lighting Retrofits: Lighting retrofits entail the replacement of inefficient lighting, such as incandescent, halogen, HID, or T12 fluorescent, with highly efficient LED lighting. Best practices include replacing existing bulbs with LEDs and installing occupancy controls, such as timers, to reduce lighting consumption when spaces are unoccupied. ENERGY STAR provides a detailed list of LED fixtures.

Weatherization Measures: Weatherization measures increase the efficiency of buildings by improving heating and cooling. These include mechanical system upgrades or improvements, health and safety measures, and building shell measures. Weatherization best practices include complete

air sealing of the facility, replacing windows and doors with triple-pane, and incorporating weather-stripping to further reduce envelope holes. For roof replacement and retrofitting, incorporating solar ready roof replacements when feasible will reduce costs of rooftop solar array installation.

Envelope/Insulation Improvements: Building envelope/insulation improvements are modifications made to a building's outer shell to improve insulation and reduce energy loss. Envelope/insulation best practices include improving insulation by utilizing R-49 if some insulation exists, or R-60 if there is none. ENERGY STAR provides a detailed list of best practices and incentive information.

HVAC Electrification and Controls Retrofit[4]: HVAC electrification and controls retrofits include the replacement of fossil-fueled HVAC system components with electrified equipment such as high-efficiency heat pumps. HVAC system retrofits must comply with any applicable building codes for HVAC system designs, efficiency ratings, or permits. Best practices for electrification include audits and assessments to determine optimal systems for specific buildings and phased implementation of new technologies. Best practices for HVAC controls include settings occupancy, pre-set heating and cooling controls to reduce demand when areas are not used and to reduce heating and cooling loads by reducing the differential from outdoor temperatures and optimize system operation. Ongoing monitoring and optimization help to ensure that system functions are meeting building needs.

Water Heating Electrification[3]: Water heating electrification includes the replacement of fossil-fueled water heating equipment with electric equipment, such as conventional storage, tankless or demand-type, and heat pump water heaters or the combination of equipment types. When feasible, tankless alternatives should be considered due to the lower energy use. Equipment replacement must plan on integration with existing plumbing and electrical systems, including upgrading panels and wiring where needed. As with HVAC equipment, ongoing monitoring and optimization of water heaters helps to ensure that system functions are meeting building needs.

Solar PV Installation

Installing rooftop solar panels on facilities can reduce onsite electricity usage, and while the grid continues to decarbonize, solar arrays will mitigate some emissions from the facility. West Tisbury has deployed a 708 kW (DC) over their capped landfill and is in the process of deploying a 65 kW (DC) at the library, which currently supply over 100% of the town's electricity usage.

Summary of Decarbonization Goals

West Tisbury's Decarbonization Strategy

Due to the electrical grid becoming cleaner over time, the overarching strategy of the decarbonization roadmap is to prioritize reducing overall energy needs at municipal facilities before investing in electrified HVAC and water heating equipment. In line with West Tisbury's fossil fuel policy, as equipment reaches the end of life, electric alternatives for replacement will be considered and when technically and financially viable they will be selected for upcoming replacements. Similarly, as zero emission vehicles become viable (both technically and financially) for medium-duty

[4] Note: The projections in this Roadmap assume that weatherization and envelope/insulation improvements will be made prior to HVAC electrification to reduce overall energy consumption. This aligns with best practices to reduce energy load prior to electrification to minimize increases in electricity use.

and heavy-duty fleet replacements, West Tisbury will invest further in decarbonizing their municipal fleet.

1. Overview of Goals for Implementation through 2030

With some recent HVAC equipment replacements made in the Library and Howes House in 2020, and the town's pursuit of zero carbon-ready retrofit study for the West Tisbury School in 2021, the town of West Tisbury has already begun working on and preparing significant ECM and EUI reduction implementation and is committed to continuing this progress through 2040. The goals laid out in this roadmap highlight the importance of conducting facility rightsizing before or during the replacement of significant heating equipment to avoid unnecessary costs. Due to the need to replace an oil fired boiler HVAC unit in the Fire Station #2 and water heating equipment replacements in facilities including the Library, Howes House, Fire Station #1, and Public Safety Building (including Fire Station #2 and Police Department) by 2027, it will be challenging for significant ECM implementation to occur during this period. Should additional funds be available during this period, weatherizing and insulation projects for the facilities that need them most should be considered during this period.

2. Overview of Goals for implementation from 2030 to 2050

As West Tisbury progresses further down the path of decarbonization, low-cost high impact opportunities are being prioritized as initial actions, and significant equipment replacement is required to complete decarbonization efforts for facilities. By delaying investments in electrified HVAC and water heating equipment, West Tisbury can leverage the existing time and goals outlined through 2030 to reduce overall energy demand. In addition, equipment alternatives by 2040 will likely be significantly cheaper than they are today.

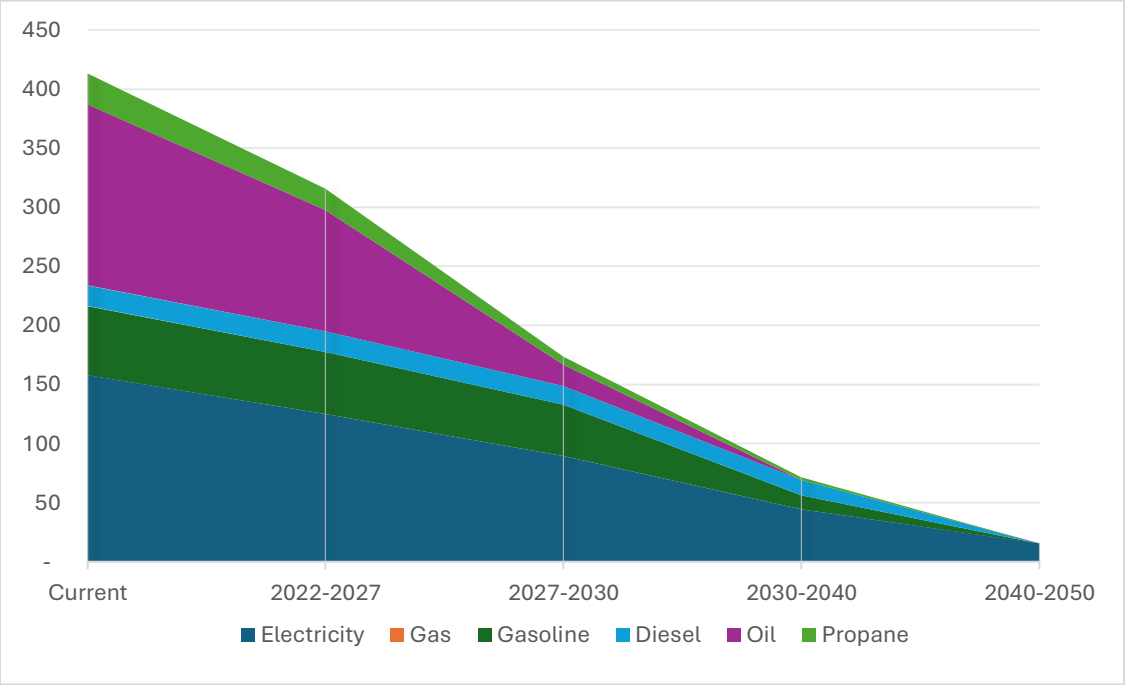
3. Areas of highest emissions and greatest opportunity for impact

West Tisbury has several large emission sources in its municipal portfolio. West Tisbury School is the largest source of emissions, and decarbonizing the school will prove to be the largest area of reduction potential in the town. This is even more pertinent considering the results of the zero carbon-ready retrofit study as there are many opportunities across ECM types for the school. Assuming no actions have been taken because of the study, the town may have to plan to commit funding earlier for retrofits and upgrades to the school than in later periods. West Tisbury will want to focus on right-sizing the school before electrification projects to minimize the required size of those systems when they are replaced.

4. Achieving Elimination of Onsite Fossil Fuel Use by 2040

The proposed implementation of ECMs over the coming two and a half decades as proposed in the following section charts a path to eliminating fossil fuels by 2040, as shown in Figure 2. West Tisbury has consistently invested in energy reduction strategies as part of its participation in the Green Communities program. Their next steps require continued commitment to decarbonizing their municipal emissions, by not only converting existing on-site fossil fuel usage to electricity by 2040 but also investing in facility energy reduction strategies to achieve EUI reduction targets

Figure 2. West Tisbury Emissions Forecast 2022 Through 2050 ($MTCO_2e$)



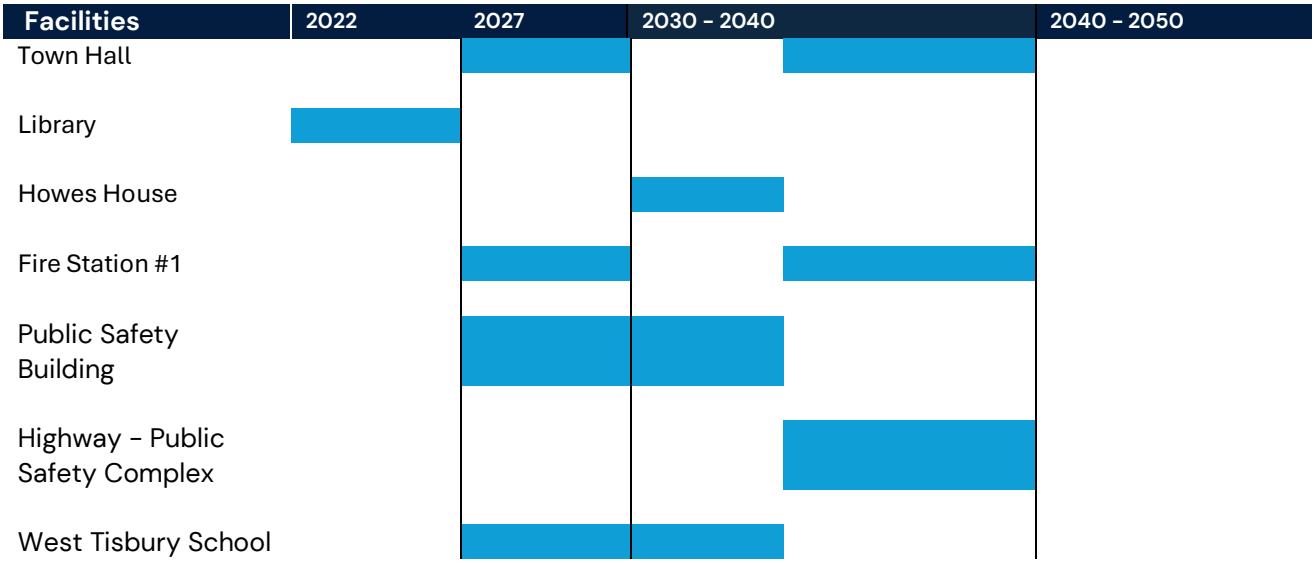
Major Trigger Events to Achieve Onsite Fossil Fuel Elimination

Trigger events are an important planning tool for portfolio level management and decarbonization. They identify key actions necessary for both the maintenance and upgrading of a facility. DOER has created a larger planning tool for municipalities to identify both regular energy audit timing, as well as end of life and capital planning for larger equipment[5]. For the purposes of this section, regular energy audits are excluded from Figure 3, however they should be planned at a regular interval for each facility to ensure that equipment is functioning properly, and the facility is in adequate condition.

This section lays out the timelines for major equipment replacements and retrofits categorized as greater than $250,000 along the timeline for 2027 – 2050. The goal of this timeline is to distribute major events over the full span of the roadmap to eliminate the occurrence of overlapping projects which may increase the risk of deviating from the roadmap. Over this time, fleet electrification will continue to occur as retirements and replacements are available.

[5] The DOER municipal trigger event workbook is listed under additional resources here - https://www.mass.gov/info-details/climate-leader-communities

Figure 3. Major Trigger Event Timeline for West Tisbury's Inventoried Buildings



Town Hall
The existing propane furnace, installed in 2009, is expected to reach end of life in the mid-2030s. Water heating electrification and any additional insulation and weatherization are recommended to be completed prior to electrifying the HVAC.

Library
The Library had hydronic heat pumps installed during 2025, and is planning to have a 65 kW (DC) array, coupled with a 185 kWh ESS, deployed in early 2026.

Howes House
Major renovation of the facility is planned towards the end of the decade to allow sufficient space between other high-priority projects.

Fire Station #1
The existing propane furnace, installed in 2017, is expected to reach end of life in the mid-2030s. Water heating electrification and any additional insulation and weatherization are recommended to be completed prior to electrifying the HVAC.

Public Safety Building
The existing heat pumps in the police station, installed in 2013 and malfunctioning, are planned to be replaced by 2030. The oil boiler in Fire Station #2 is also planned to be replaced during this phase.

Water heating electrification and any additional insulation and weatherization are recommended to be completed prior to electrifying the HVAC.

Highway – Public Safety Complex
The existing propane furnace, installed in 2016, is expected to reach end of life in the late-2030s. Water heating electrification and any additional insulation and weatherization are recommended to be completed prior to electrifying the HVAC.

West Tisbury School
As the largest facility within the decarbonization roadmap, the West Tisbury School decarbonization will be broken out over 3 phases, with the first phase occurring in 2028-30 which will weatherize, insulate, and prepare the HVAC infrastructure in the 1973 wing for electrification in the early 2030s. The second phase will be to weatherize, insulate, and prepare mechanicals in the 1985 wing. Weatherization and electrification of the HVAC mechanicals and hot water of the 1994 wing (phase 3) are planned to occur in the mid 2030s.

Co-Benefit Considerations

In addition to supporting emissions reductions and decarbonization goals, these strategies can also provide co-benefits to the community by improving human health, economic development opportunities, and increased building resilience. Energy efficiency upgrades and the deployment of on-site renewable resources can help to mitigate impacts from extreme heat or cold and power outages. The decarbonization strategies identified in this Roadmap can deliver co-benefits as investments in West Tisbury's community.

Program Management Plan for Implementation, Monitoring and Oversight

Lead Implementers

With the support of stakeholders, funding, and this guiding Roadmap, West Tisbury will begin implementing actions and strategies to achieve the town's decarbonization goals. Implementation of this multi-year Roadmap will require support and action from West Tisbury government (Selectboard, Capital Improvement Committee, Facilities & Maintenance Committee, and the Energy Committee), the UIRSD and residents. The Roadmap provides a strategic, portfolio-level approach to prioritize and implement decarbonization measures at West Tisbury's buildings.

The actions identified in this Roadmap will require ongoing evaluation and strategic planning to incorporate building upgrades into existing budget processes or to identify additional funding sources where needed. Staff resources will also be necessary to support the implementation of these actions. Over time, as implementation progresses and technologies and policies evolve, West Tisbury will also update this 2025 Roadmap to reflect accomplishments and new opportunities.

Roadmap Maintenance

The West Tisbury Energy Committee and the UIRSD Committee will be primarily responsible for maintaining this Roadmap and monitoring progress toward the 2050 goal and updating MEI with ECM implementation and realized emission reductions on their path to net-zero.

Facility Level Recommendations

Facility Level Recommendations to Achieve Onsite Fossil Fuel Elimination

The following sections outline the recommended ECMs on a facility level basis to be implemented and a proposed timeline to avoid unrealistic implementation timing based on logistic and financial constraints. The goal of these profiles is to outline on a facility level what types of projects should be implemented and in what order to best match the needs of the facility with the decarbonization steps required. At the core of each facility's recommendation is the goal of reducing overall energy consumption for the facility to an efficient level before investing in replacement equipment that decarbonizes the facility.

In cases where equipment fails prior to the expected replacement year, this roadmap can serve as a tool for facility managers to identify replacement equipment well in advance of the end of lifespan. By maintaining the roadmap with implemented projects and planned replacements, West Tisbury can leverage the timing of replacements to best match the available offerings in the market and customize their decarbonization pathway to best suit the needs and limitations of the town in a given year.

Town Hall

Baseline:

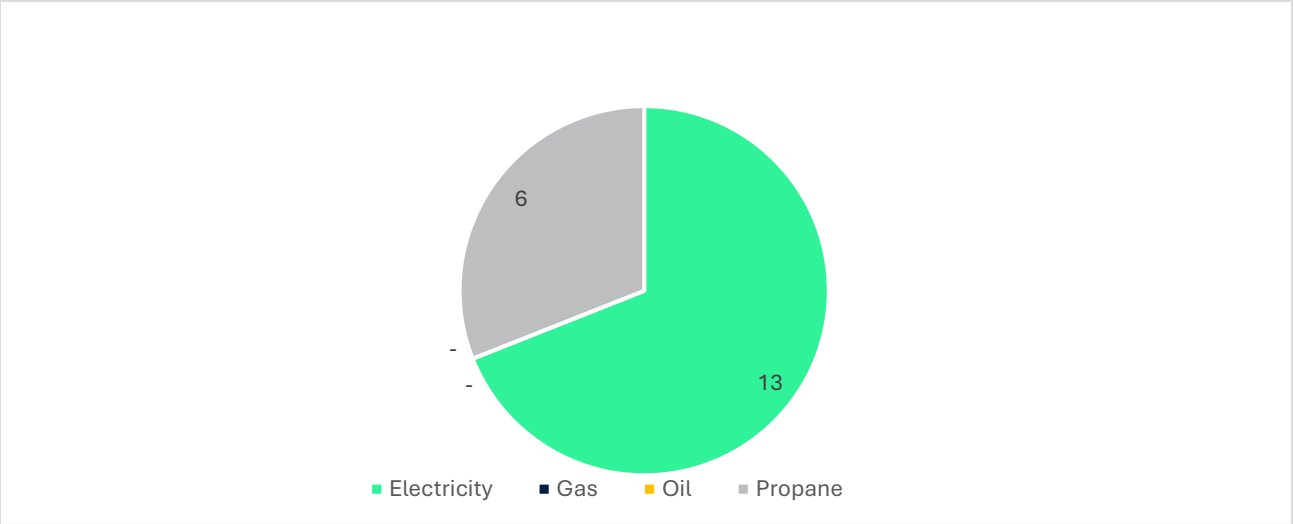
The emissions by fuel types used at the Town Hall during FY2022 are shown in Figure 4.

Building Characteristics	
Year Built/Major Renovation	2008
Square Footage	6,658
Future Plans	Keep
GHG FY22 (MTCO2e)	18.9
EUI FY22 (kBtu/sf)	41.33
Building Condition	Fair

Improvement Goals

The Town Hall utilizes electricity and propane for energy consumption in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement all weatherization and insulation projects prior to investing in electrifying HVAC and converting electric resistance water heaters to heat pump hot water. This roadmap proposes implementing weatherization and envelope projects by 2030 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 4: Town Hall Emissions (FY22 - $MTCO_2e$)



By implementing the proposed decarbonization plan in Table 4**Error! Reference source not found.**, the projected building emissions for the Town Hall are described in Figure 5. Due to the expected costs in the 2022-2027 period, this proposed timeline delays electrifying both the HVAC and water heating until at least 2030 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment, but addresses critical equipment needs. Note that the time periods presented in **Error! Reference source not found.** may not directly align with the proposed ECM implementation in **Error! Reference source not found.**. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027 period, and the HVAC and

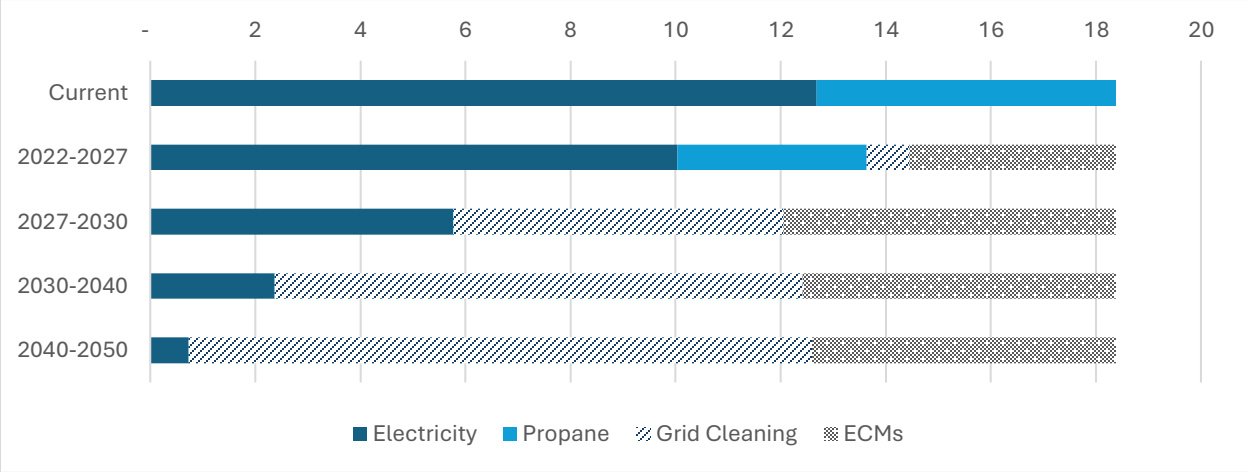
water heating systems being electrified in the 2027 – 2030 period. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 4: Town Hall Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	20.38
FY2027	**Weatherization Measures**	$	11.86
FY2027	**Envelope/Insulation Improvements**	$$$	29.66
FY2030	**HVAC Electrification and Controls Retrofit**	$$$	41.29
FY2030	**Water Heating Electrification**	$$	1.74

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 5: Town Hall Estimated Future Building Emissions based on the Building Plan ($MTCO_2e$)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the Town Hall shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

Baseline:

The emissions by fuel types used at the Library during FY2022 are shown in **Error! Reference source not found.**.

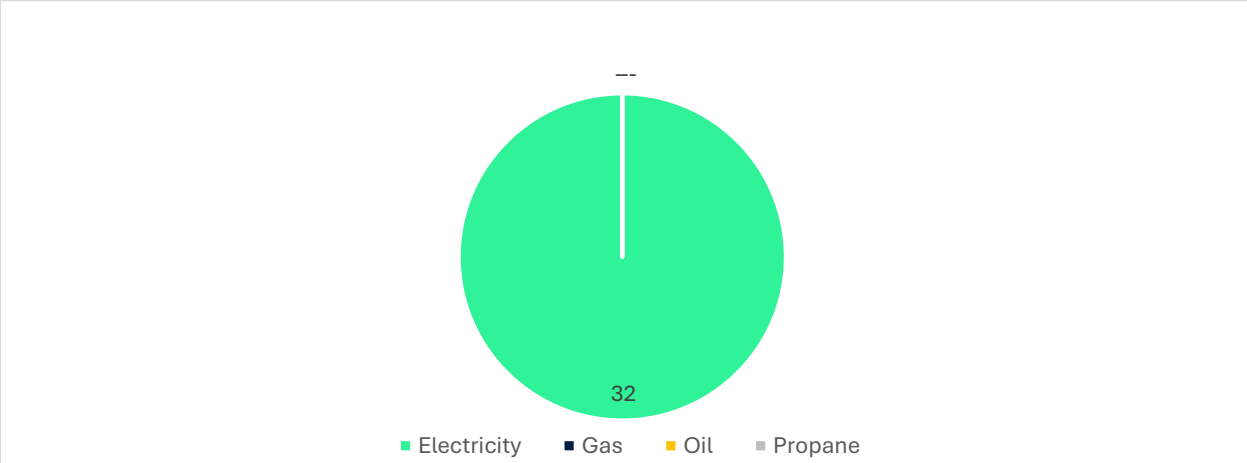
Recent ECMs that have been implemented include installing a hydronic heat pump as of 2025 and the building has multiple Energy Recovery Ventilators (ERVs) that assist with reducing energy consumption for HVAC.

Building Characteristics	
Year Built/Major Renovation	1992/2014
Square Footage	8,101
Future Plans	Keep
GHG FY22 (MTCO2e)	33.6
EUI FY22 (kBtu/sf)	58.31
Building Condition	Excellent

Improvement Goals

The Library utilizes primarily electricity in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement any additional weatherization and insulation projects, and replacing the electric water heater in the next 5-10 years. This roadmap proposes implementing weatherization and envelope projects by 2030 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 6: Library Emissions (FY22 - $MTCO_2e$)



By implementing the proposed decarbonization plan in Table 5**Error! Reference source not found.**, the projected building emissions for the Library are described in Figure 7. Due to the expected costs in the 2022-2027 period, this proposed timeline delays electrifying the HVAC until at least 2040 and the water heating until at least 2030 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment but address recurring equipment replacement needs. Note that the time periods presented in Figure 7 may not directly align with the proposed ECM implementation in **Error! Reference source not found.**. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027 period, and the HVAC and water heating systems being

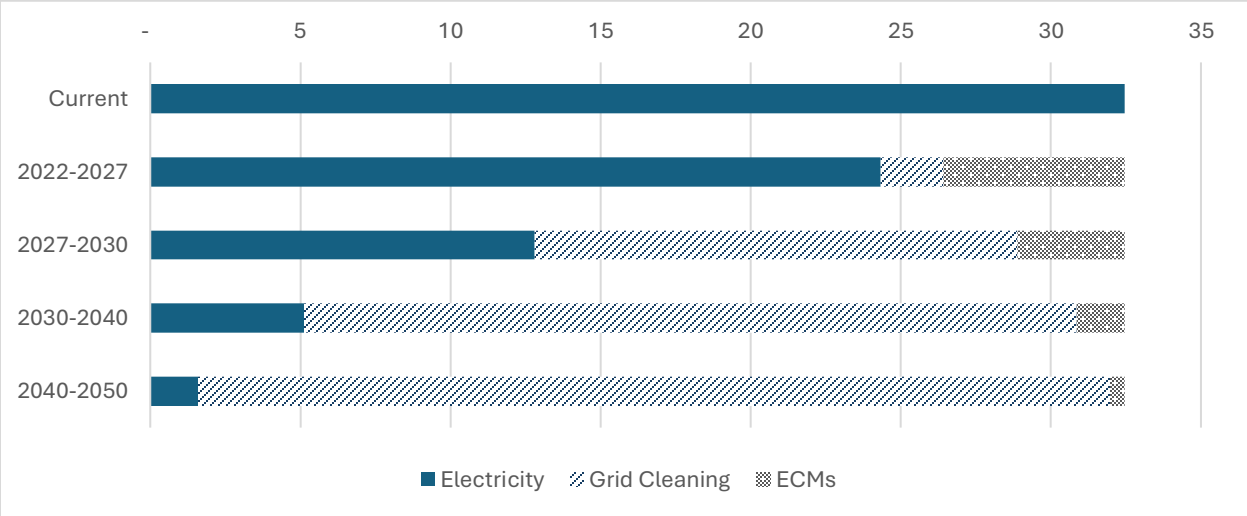
electrified in the 2030 – 2040 and 2027 - 2030 periods respectively. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 5. Library Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2030	**Lighting**	$	39.42
FY2030	**Weatherization Measures**	$$	15.64
FY2030	**Envelope/Insulation Improvements**	$$$	39.09
FY2024-25	**HVAC Electrification and Controls Retrofit**	$$	9.21
FY2024-25	**Water Heating Electrification**	$$	9.21

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 7. Library Estimated Future Building Emissions based on the Building Plan ($MTCO_2e$)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the Library shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

In addition to the proposed EUI reduction and system electrification projects, the Library's roof is a prime candidate for a rooftop solar array that would add to the facility's decarbonization path. An estimated 65 kW array has been contracted to be installed on the roof in early 2016, which would generate an estimated 78,000 kWh of electricity annually.

Howes House

Baseline:

Howes House hosts the regional Up-island Council on Aging. The region consists of West Tisbury, Chilmark, and Aquinnah. There is plans to re-model the facility, which would include decarbonization and weatherization, sometime between 2027-2035. Current mechanical systems (non-cold climate) are air sourced heat pumps and a gas fired boiler for radiant heat and hot water. The heat pumps have supplemental heat coils to provide additional heating capacity. The emissions by fuel types used at the Howes House during FY2022 are shown in **Error! Reference source not found.**.

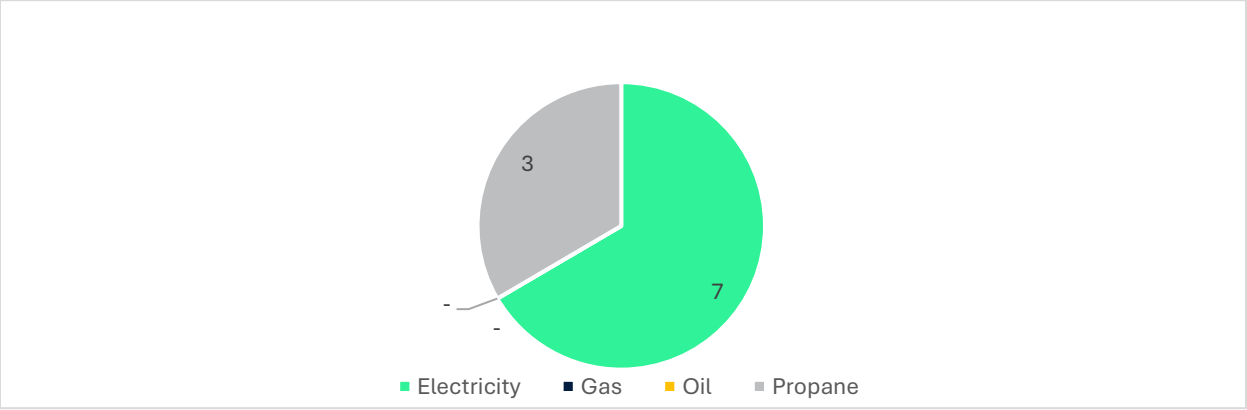
Building Characteristics	
Year Built/Major Renovation	1800
Square Footage	2,864
Future Plans	Keep
GHG FY22 (MTCO2e)	10.2
EUI FY22 (kBtu/sf)	51.82
Building Condition	Fair

Recent ECMs that have been implemented include installing a new high-efficiency propane boiler, replacement fuel tank, and condensate pump in 2020.

Improvement Goals

The Howes House utilizes primarily electricity and propane in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement all weatherization and insulation projects prior to investing in electrifying HVAC and water heaters. This roadmap proposes implementing weatherization and envelope projects by 2030 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 8: Howes House Emissions (FY22 - $MTCO_2e$)



By implementing the proposed decarbonization plan in Table 6, the projected building emissions for the Howes House are described in Table 6. Howes House Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	8.13

FY2027	**Weatherization Measures**	$$	6.49
FY2027	**Envelope/Insulation Improvements**	$$$	16.22
FY2040	**HVAC Electrification and Controls Retrofit**	$$$	7.71
FY2030	**Water Heating Electrification**	$$	0.66

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 9**Error! Reference source not found.**. Due to the expected costs in the 2022-2027 period, this proposed timeline delays electrifying the HVAC until 2040 and the water heating until at least 2030 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment but address recurring equipment replacement needs. Note that the time periods presented in Table 6. Howes House Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	8.13
FY2027	**Weatherization Measures**	$$	6.49
FY2027	**Envelope/Insulation Improvements**	$$$	16.22
FY2040	**HVAC Electrification and Controls Retrofit**	$$$	7.71
FY2030	**Water Heating Electrification**	$$	0.66

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

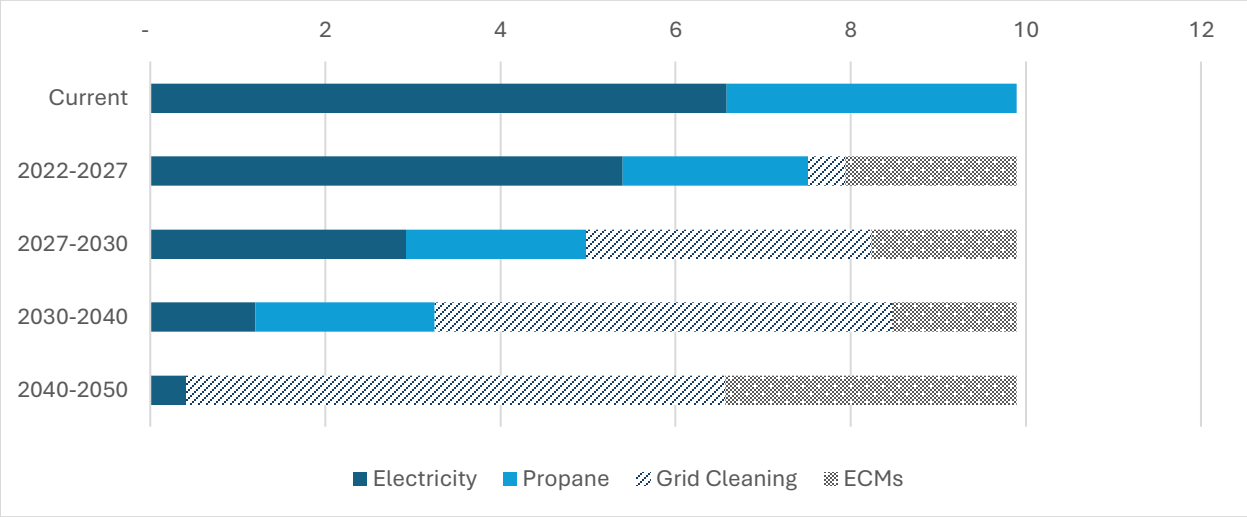
Figure 9 may not directly align with the proposed ECM implementation in Table 6. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027 period, and the HVAC and water heating systems being electrified in the 2040 – 2050 and 2027 - 2030 periods respectively. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 6. Howes House Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	8.13
FY2027	**Weatherization Measures**	$$	6.49
FY2027	**Envelope/Insulation Improvements**	$$$	16.22
FY2040	**HVAC Electrification and Controls Retrofit**	$$$	7.71
FY2030	**Water Heating Electrification**	$$	0.66

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 9: Howes House Estimated Future Building Emissions based on the Building Plan (MTCO2e)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the Howes House shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

Fire Station #1

Baseline:

The emissions by fuel types used at the Fire Station #1 during FY2022 are shown in **Error! Reference source not found.**.

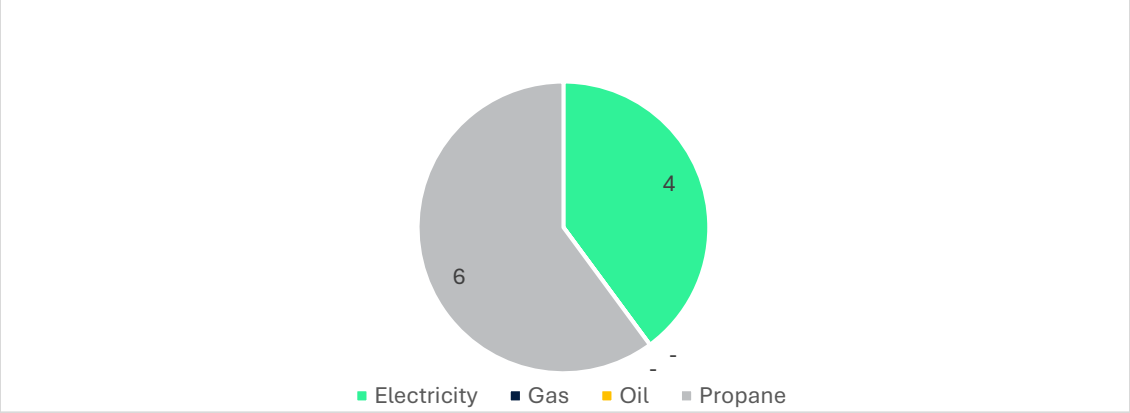
There are no recent ECMs to report for the Fire Station #1. Air compressors to support the HVAC system were installed in 2018 and a hot water electric heater was installed in 2017, which means replacements for this equipment will be necessary, but not immediately.

Building Characteristics	
Year Built/Major Renovation	1950
Square Footage	3,012
Future Plans	Keep
GHG FY22 (MTCO2e)	10.0
EUI FY22 (kBtu/sf)	49.73
Building Condition	Fair

Improvement Goals

The Fire Station #1 utilizes primarily propane and electricity in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement all weatherization and insulation projects prior to investing in electrifying HVAC and water heaters. This roadmap proposes implementing weatherization and envelope projects by 2030 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 10. Fire Station Emissions (FY22 - $MTCO_2e$)



By implementing the proposed decarbonization plan in Table 7, the projected building emissions for the Fire Station #1 are described in Figure 11. Due to the expected costs in the 2022-2027 period, this proposed timeline delays electrifying the HVAC until at least 2030 and the water heating until at least 2040 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment but address recurring equipment replacement needs. Note that the time periods presented in Figure 11 may not directly align with the proposed ECM implementation in Table 7. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027

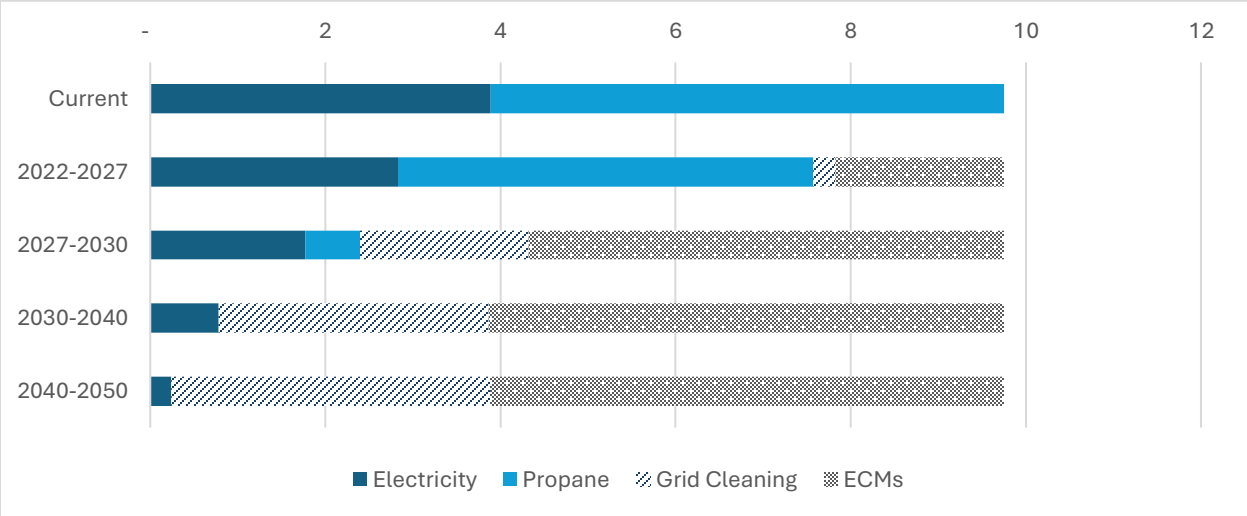
period, and the HVAC and water heating systems being electrified in the 2027 – 2030 and 2030 - 2040 periods respectively. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 7. Fire Station #1 Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	8.89
FY2027	**Weatherization Measures**	$$	8.93
FY2027	**Envelope/Insulation Improvements**	$$$	12.51
FY2030	**HVAC Electrification and Controls Retrofit**	$$$	28.60
FY2040	**Water Heating Electrification**	$	5.95

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 11. Fire Station #1 Estimated Future Building Emissions based on the Building Plan ($MTCO_2e$)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the Fire Station shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

Public Safety Building

Baseline:

The emissions by fuel types used at the Public Safety Building (PSB), which included Fire Station #2 and the Police Department during FY2022 are shown in **Error! Reference source not found.**.

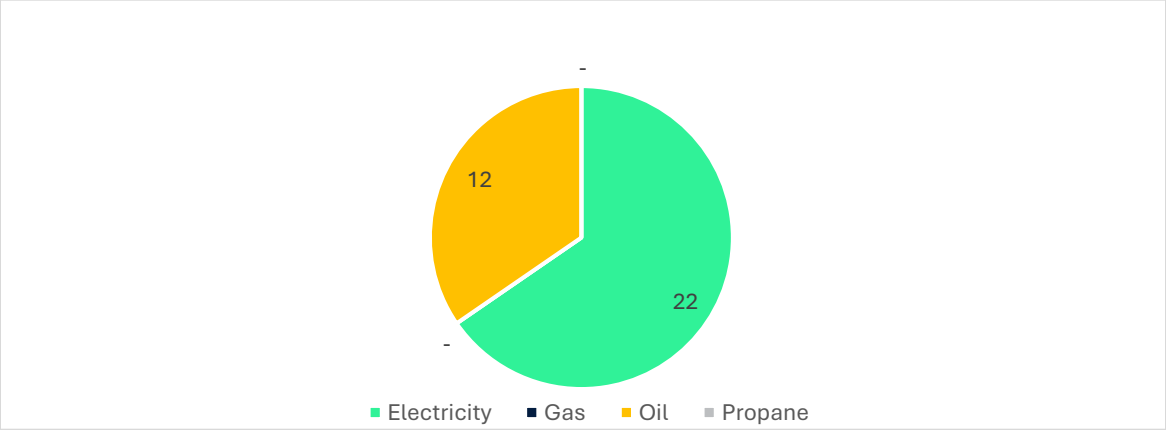
There are no recent ECMs to report on for the PSB. Much of the HVAC equipment such as heat pumps, fan coils, and electric heaters were installed in 2013, which means replacements for this equipment will be necessary, but not immediately.

Building Characteristics	
Year Built/Major Renovation	1999/2016
Square Footage	3,678
Future Plans	Keep
GHG FY22 (MTCO2e)	34.4
EUI FY22 (kBtu/sf)	130.26
Building Condition	Fair

Improvement Goals

The PSB utilizes primarily electricity and oil in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement all weatherization and insulation projects prior to investing in electrifying HVAC and water heaters. This roadmap proposes implementing weatherization and envelope projects by 2030 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 12. PSB Emissions (FY22 - $MTCO_2e$)



By implementing the proposed decarbonization plan in Table 8, the projected building emissions for the PSB are described in Figure 13. Due to the expected costs in the 2022-2027 period, this proposed timeline delays electrifying the HVAC until at least 2040 and the water heating until at least 2030 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment but address recurring equipment replacement needs. Note that the time periods

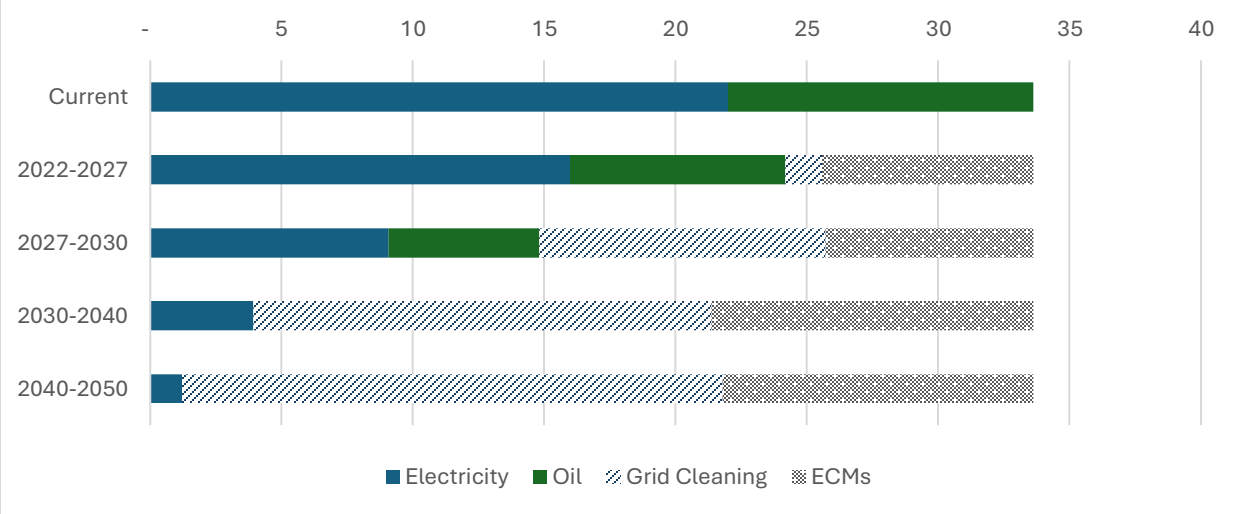
presented in Figure 13 do not directly align with the proposed ECM implementation in Table 8. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027 period, and the HVAC and water heating systems being electrified in the 2030 – 2040 and 2027 - 2030 periods respectively. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 8. PSB Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$	50.27
FY2027	**Weatherization Measures**	$$	19.51
FY2027	**Envelope/Insulation Improvements**	$$$	48.77
FY2040	**HVAC Electrification and Controls Retrofit**	$$$	58.03
FY2030	**Water Heating Electrification**	$$	20.32

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 13. PSB Estimated Future Building Emissions based on the Building Plan ($MTCO_2e$)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the PSB shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

In addition to the proposed EUI reduction and system electrification projects, the PSB's roof is a prime candidate for a rooftop solar array that would add to the facility's decarbonization path. An estimated 20-41 kW array could be installed on the roof, which would generate an estimated 28,000-58,000 kWh of electricity annually.

West Tisbury School

Baseline:

The emissions by fuel types used at the West Tisbury School during FY2022 are shown in Figure 15.

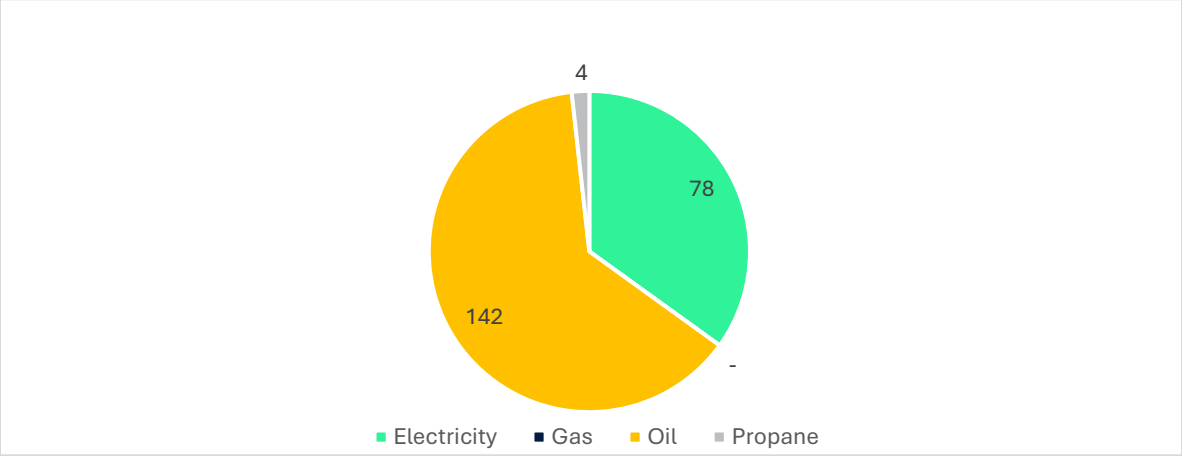
Recent ECMs that have been implemented include replacing LED lighting on all fixtures as of 2022. It also has replaced many if not all the windows and doors at some point from the originals.

Building Characteristics	
Year Built/Major Renovations	1973/1985/1994
Square Footage	61,000
Future Plans	Keep
GHG FY22 (MTCO2e)	227.1
EUI FY22 (kBtu/sf)	51.46
Building Condition	Fair

Improvement Goals

The West Tisbury School utilizes primarily oil and electricity in the baseline year of FY2022. The primary goals of decarbonizing these offices are to implement all weatherization and insulation projects prior to investing in electrifying HVAC and water heaters, or at the same time in a phased approach across the various sections of the structure defined as the 1973, 1985, and the 1994 wings. This roadmap proposes implementing weatherization and envelope projects by 2027 to reduce the overall building's energy usage while allowing time for capital improvement plans to be developed for the HVAC and water heater upgrades.

Figure 14: West Tisbury School Emissions (FY22 - MTCO2e)



By implementing the proposed decarbonization plan in Table 9, the projected building emissions for the West Tisbury School are described in Figure 15**Error! Reference source not found.**. Due to the large size of the West Tisbury School and many needed improvements to the building as of the zero-

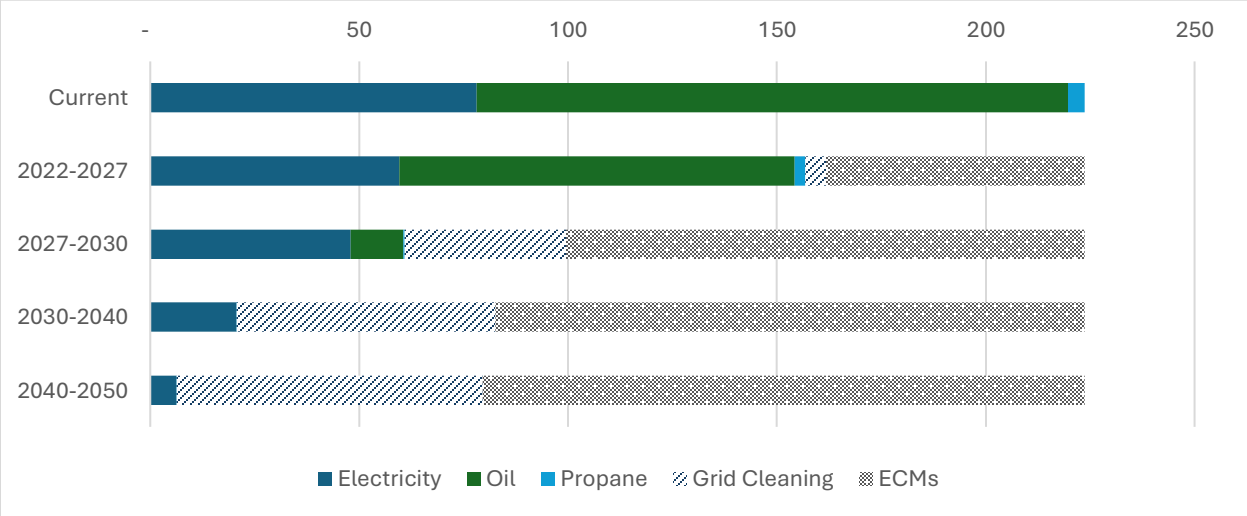
carbon study in 2021, equipment upgrades will be significant costs to the school. This proposed timeline delays electrifying HVAC until at least 2030 and water heating until at least 2040 to allow sufficient time to reduce EUI for the facility prior to investing in significant equipment. Note that the time periods presented in Figure 15**Error! Reference source not found.** may not directly align with the proposed ECM implementation in Table 9. The proposed timeline involves weatherization and envelope upgrades occurring during the 2022 – 2027 period, HVAC upgrades occurring in the 2027-2030 period, and water heating systems being electrified in the 2030 – 2040 period. Emission reductions outside of those periods are the result of the lower emission factors for electricity.

Table 9: West Tisbury Decarbonization Plan

Implemented By	Proposed Strategy	Estimated Cost	Energy Savings (MMBTU)
FY2027	**Lighting**	$$	129.01
FY2027	**Weatherization Measures**	$$	213.13
FY2027	**Envelope/Insulation Improvements**	$$$	532.83
FY2030	**HVAC Electrification and Controls Retrofit**	$$$	551.41
FY2040	**Water Heating Electrification**	$$	106.19

Note: Estimates costs determination is detailed in the technical appendix, and values are based on national averages for building categories and sizes. These estimates are not intended to replace actual project cost estimation.

Figure 15: West Tisbury School Estimated Future Building Emissions based on the Building Plan (MTCO2e)



Note: As the emission factor for electricity decreases over time, baseline electricity usage generates fewer emissions. As a result, the emission forecast for the decarbonization of the West Tisbury School shows a combination of both ECM implementation and grid cleaning to result in the decarbonized facility by 2040.

Other Buildings

Baseline:

As mentioned at the beginning of the Municipal Building Portfolio section, this roadmap includes the majority of West Tisbury's municipal emissions. However, there exist other buildings and facilities not included in the formal roadmap process, that for completeness are included here. Due to a lack of data, the details included in this section will be fewer than those presented for the preceding buildings and facilities.

The Highway – Public Safety Complex (PSC) did not have a lot of facility conditions reported but had a heat pump and boiler installed in 2016. Based on a 20-year EUL assumption, the town may consider replacing this equipment in 2036. The town may also consider pursuing some of the other ECMs such as lighting, envelope/weatherization, and insulation if needed. The Highway - PSC's roof is a candidate for a rooftop solar array that would add to the facility's decarbonization path. An estimated 20-41 kW array could be installed on the roof, which would generate an estimated 28,000-58,000 kWh of electricity annually.

The Mill Pond Building has intermittently been leased to private individuals but is included in the roadmap as it may return to municipal management in the future. The town may also consider pursuing some of the other ECMs such as lighting, envelope/weatherization, and insulation if needed.

Table 10: Other Building Emission Baselines

Building Name	Year Built	Square Footage	Plans	GHG FY22 (MTCO2e)	EUI FY22 (kBtu/sf)
Highway - PSC	2017	3,700	Keep	9.7	40.2
Mill Pond Building	1880	980	Keep	0.0	0.0

Improvement Goals

As noted in the baseline inventory, the recommendations for other buildings will be provided at a high level by category. The timeline for proposed adoption will assume a uniform decrease in building emissions over time. These buildings should be regularly assessed to make sure equipment is functioning properly and receiving appropriate repairs. As discussed before, emphasizing the weatherization and insulation of a facility prior to the retrofitting of central HVAC or water heating systems is key to achieving EUI targets outlined in this roadmap. In addition to the proposed EUI reduction and system electrification projects, where roof aspects are favorable, Aquinnah should consider implementing rooftop arrays at their other facilities.

Vehicles

Vehicles

In FY2022, the municipal fleet of West Tisbury generated about 22% of overall municipal emissions.

Light-Duty Vehicles

Within the municipal fleet of West Tisbury, 44.1% of the fleet is comprised of light-duty vehicles. West Tisbury has no current plans to add or reduce the number of vehicles in their light-duty fleet. The targeted percentage of light-duty ZEV vehicles in the fleet is detailed in Table 2. Summary of Municipal Emissions Reductions, with a consistent adoption of vehicles as they reach retirement age.

Medium-Duty Vehicles

Within the municipal fleet of West Tisbury, 14.7% of the fleet is comprised of medium-duty vehicles. West Tisbury has no current plans to add or reduce the number of vehicles in their medium-duty fleet. The targeted percentage of medium-duty ZEV vehicles in the fleet is detailed in Table 2. Summary of Municipal Emissions Reductions. Due to the current lack of many technically feasible electric vehicles that fit medium-duty functions, transitioning of the fleet will be slower than the light-duty fleet.

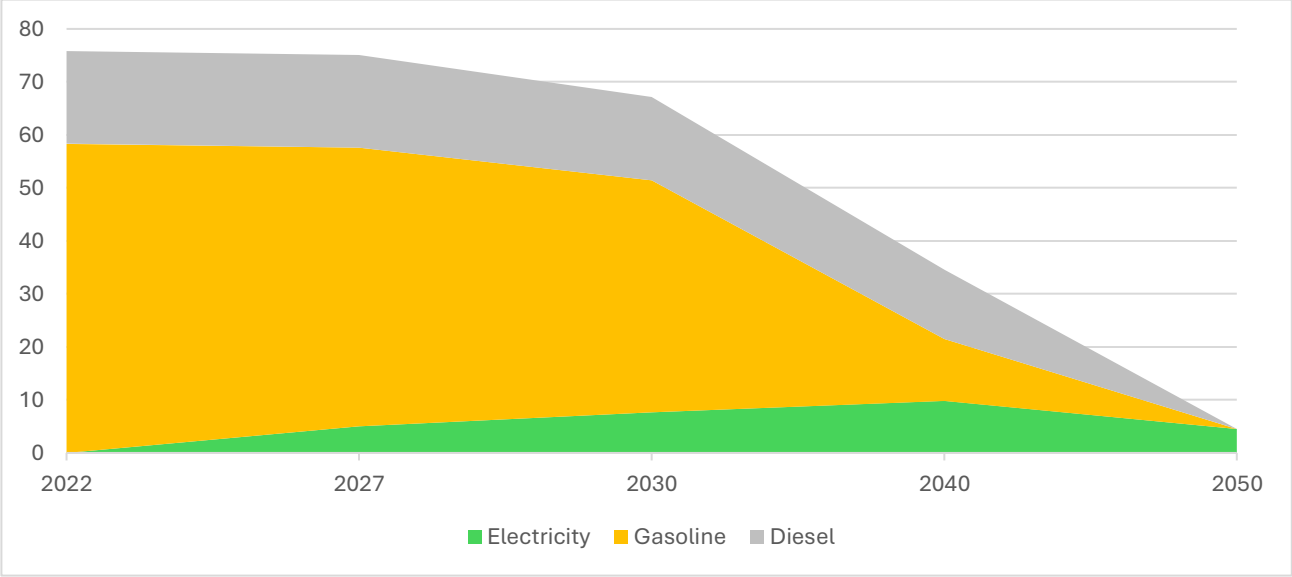
Heavy-Duty Vehicles

Within the municipal fleet of West Tisbury, 41.2% of the fleet is comprised of heavy-duty vehicles. West Tisbury has no current plans to add or reduce the number of vehicles in their heavy-duty fleet. A replacement plan will be developed when the current limitations on available heavy-duty vehicles are less restrictive.

Estimated Municipal Fleet Emissions

By transitioning the municipal fleet based on the Table 2. Summary of Municipal Emissions Reductions, estimated municipal fleet emissions are shown in Figure 16 below.

Figure 16. Emission Profile of Electric Vehicle Adoption ($MTCO_2e$)



Technical Appendix

Technical Appendix

West Tisbury utilized a modeling tool developed for the purposes of this Roadmap to estimate the emissions reduction potential from a range of potential energy conservation measures (ECMs). The tool incorporated existing building characteristics data and business-as-usual (BAU) fuel use and costs from Fiscal Year 2022 (FY2022), in addition to known information about retrofit and upgrades completed to date for each building, to estimate the impact of implementing a range of ECMs. The tool inputs and assumptions are described in this Appendix.

Data Sources and Assumptions

The baseline emissions profile for the town's portfolio and by building was sourced from MEI.
The tool used the below emission factors from MA EEA's forecasting for each fuel type. These estimates were produced as part of the MA 2050 Decarbonization Roadmap and were forecasted for every 5 years from 2020 to 2050. For estimating emissions in this roadmap, the 2025 emission factor for electricity is being applied to the 2027 period. The roadmap acknowledges that local emission factors for West Tisbury are below the state average due to the use of Hudson Light and Power, which has a much greener portfolio of energy generation than the state currently.

	2022	2025	2030	2040	2050
Electricity (kWh)	0.000235	0.00022	0.000118	0.0000485	0.000015
Gas (therms)	0.00531	0.00531	0.00531	0.00531	0.00531
Oil (gallons)	0.01015	0.01015	0.01015	0.01015	0.01015
Propane (gallons)	0.00576	0.00576	0.00576	0.00576	0.00576

Source: MA EEA

Building Characteristics & Energy Consumption

The tool used building characteristics data from MEI including total fuel use, EUI, and square footage for each building. The fuel use by type data included FY2022 totals for electric, gas, oil, propane, and total fuel use for each building. The fuel costs by type were also FY2022 totals for each applicable fuel type. For each building, the MEI building category was mapped to an EIA building category to apply the most appropriate building assumptions for each facility type.

MEI	EIA Match
Administration	Office
Indoor Recreation	Public Assembly
Library	Public Assembly
Public Safety	Public Order and Safety
Public Works	Service

School	Education
Other	Other

The tool used Commercial Building Energy Consumption by End Use factors from the U.S. Energy Information Administration (EIA) Commercial Buildings Energy Consumption Survey to estimate each facility's energy consumption by end use to estimate reductions from each ECM.[6] These factors provided the percentage of total consumption for each end-use by energy source.

Energy Conservation Measures

ECM implementation timelines aligned with the Roadmap timeline structure (2022-2027, 2027-2030, 2030-2040, 2040-2050) and enabled short-, medium-, and long-term assumptions for each ECM type based on available facility data and cost estimations. Existing ECMs information in MEI, and additional resources and information sources where applicable, were used to determine each building's eligibility for additional Energy Conservation Measures (ECMs) with 100% being fully eligible, i.e. having not implemented the ECM to any extent, and 0% being ineligible, i.e. having already fully implemented that ECM or the ECM is not applicable or appropriate for that building. Where no data was available, the tool assumed 100% eligibility for that ECM.

[6] Table E5 and E7, Commercial Buildings Energy Consumption Survey (CBECS), 2018 https://www.eia.gov/consumption/commercial/data/2018/index.php?view=consumption

Building Name	Fuel Use Total	Fuel Use Total	EUI	Building Square Footage	Eligibility for Additional Energy Conservation Measures (100%=Eligible, 0%=Not Eligible. Percentages indicate amount already completed.)					
	MMBtu	kBtu	kBtu/sf	sq. ft.	Lighting	Weatherization	Envelope/ Insulation	HVAC Controls	HVAC Electrification	Water Heating Electrification
Town Hall	275.2	275,200	41.33	6,658	100%	100%	100%	100%	100%	100%
Library	472.4	472,400	58.31	8,101	100%	100%	100%	50%	50%	100%
Howes House	148.4	148,400	51.82	2,864	100%	100%	100%	100%	100%	100%
Fire Station #1	149.8	149,800	49.73	3,012	100%	100%	100%	70%	70%	50%
PSB	479.1	479,100	130.26	3,678	100%	100%	100%	100%	100%	100%
Highway - PSC	148.6	148,600	40.16	3,700	100%	100%	100%	80%	80%	100%
West Tisbury School	3,139.0	3,139,000	51.46	61,000	100%	100%	100%	100%	100%	100%

*greyed rows indicate no available ECM data on MEI

The eligibility assumptions were incorporated into the ECM calculations for each building, using the assumptions and factors described below. **Note:** the HVAC Electrification and Controls Retrofit calculations use the estimated energy consumption following implementation of the Weatherization and Envelope/Insulation Improvements. This assumption requires a phased approach where all weatherization and envelope/insulation measures are implemented prior to any electrification measures.

Lighting Retrofits

To estimate lighting end-use consumption reductions from lighting retrofits, the tool used the matched building type, building square footage, and electricity usage to estimate the lighting end-use consumption. The estimated lighting end-use consumption was multiplied by an Expected Electricity Savings assumption of 66% (based on Averaged PNNL Study based on Design Lights Case Studies[7]) to estimate the total reduction potential from lighting retrofits.

To estimate total implementation costs per facility, the tool applied the following cost per unit assumption:

Description	Cost	Unit
LED retrofit w/ photocells	$3.15	$/sqft

Cost estimates do not account for prevailing wage requirements in Massachusetts.

Weatherization

To estimate energy savings from weatherization measures, the tool used the matched building type, building square footage, and applicable fuel usage to estimate the HVAC end-use consumption. For each applicable fuel type per building, the estimated HVAC end-use consumption was multiplied by an Expected Electricity Savings assumption of 8% (ICF assumption[8]) and an Expected Gas/Fuel Savings assumption of 12% (ICF assumption) to estimate the total reduction potential from weatherization measures.

To estimate total implementation costs per facility, the tool applied the following cost per unit assumption:

Description	Cost	Unit
Weatherization Measures	$5.00[9]	$/sqft

Cost estimates do not account for prevailing wage requirements in Massachusetts.

Envelope/Insulation Improvements

To estimate energy savings from envelope/insulation improvements, the tool used the matched building type, building square footage, and applicable fuel usage to estimate the HVAC end-use consumption. For each applicable fuel type per building, the estimated HVAC end-use consumption was multiplied by an

[7] https://www.designlights.org/our-work/networked-lighting-controls/lighting-controls-case-studies/

[8] Weatherization and Envelope/Insultation improvement energy reduction potentials were derived from ICF industry experience in alignment with recent studies completed and reduction potentials from commercial buildings. Since reduction potentials of building envelope vary based on investment, higher cost and reductions potentials were used for the Envelope/Insulation Improvements. https://www.insulate.org/ICFStudy2022.pdf

[9] ICF assumption.

Expected Electricity Savings assumption of 20% (ICF assumption) and an Expected Gas/Fuel Savings assumption of 30% (ICF assumption) to estimate the total reduction potential from envelope/insulation improvements.

To estimate total implementation costs per facility, the tool applied the following cost per unit assumption:

Description	Cost	Unit
Building Envelope Retrofit	$19.50[10]	$/sqft

Cost estimates do not account for prevailing wage requirements in Massachusetts.

HVAC Electrification and Controls Retrofit

To estimate energy savings from HVAC electrification and controls retrofits, the tool used the matched building type, building square footage, and applicable fuel usage (using the projected reduced fuel usage following implementation of any weatherization and envelope/insulation improvements) to estimate the HVAC end-use consumption. For each applicable fuel type per building, the estimated HVAC end-use consumption was multiplied by an Expected Electricity Savings assumption of 10% (ICF assumption) and an Expected Gas/Fuel Savings assumption of 10% (ICF assumption) to estimate the total reduction potential from HVAC electrification and controls retrofits.

Energy savings from increased efficiency of heat pump are estimated using a coefficient of performance (COP) of 2.5. This results in a 60% reduction in HVAC energy demand for a building after the HVAC retrofit has occurred. Current data on realized COP values is limited for non-residential properties. The COP of 2.5 used in this model is based on a range of values from 1.00 – 3.50 based on heating degree days, with lower COPs occurring in high heating degree day regions[11]. The value of 2.5 is associated with 7,000 heating degree days, which provides a conservative estimate.

To estimate total implementation costs per facility, the tool applied the following cost per unit assumption:

Description	Cost	Unit
Building Automation System	$3.00[12]	$/sqft
HVAC Electrification	$17.87[13]	$/sqft

Cost estimates do not account for prevailing wage requirements in Massachusetts.

Water Heating Electrification

To estimate energy savings from electrifying existing natural gas-fired water heaters, the tool used the matched building type, building square footage, and applicable fuel usage to estimate the water heating end-use consumption. For each applicable fuel type per building, the estimated water heater end-use consumption in fossil fuels was estimated using building characteristic data and then transformed to electricity use assuming an existing hot water heater with an Uniform Efficiency Factor (UEF) efficiency of

[10] Based on an average cost between $11.00-28.00 provided in Transformative Building Envelope Retrofit Using Insulation-Inflatable Walls Assisted by Automation, 2021. Source: info.ornl.gov/sites/publications/Files/Pub172058.pdf.
[11] ACEEE Electrifying Space Heating in Existing Commercial Buildings
[12] Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS) Data
[13] Energy Home, DEP, Montgomery County, MD (montgomerycountymd.gov)

80% and new heat pump water heater with a UEF of 2 to estimate the total energy change from water heater electrification.

To estimate total implementation costs per facility, the tool applied the following cost per unit assumption:

Description	Cost	Unit
Water Heater Electrification	$6.30[14]	$/sqft

Cost estimates do not account for prevailing wage requirements in Massachusetts.

Solar PV

To estimate solar eligibility and system size, the tool used estimates from NREL's PVWatts® Calculator.[15] This calculator estimates the energy production of grid-connected photovoltaic (PV) energy systems throughout the world based on a rooftop size estimator using aerial images of the facility. Each facility was searched on PVWatts® to determine whether it was a good candidate for a PV system and, if determined to be an eligible candidate, the simulated outputs from PVWatts® were integrated into the tool. These outputs included the estimated DC system capacity (KW) and estimated solar generation annually (kWh). In addition to the results provided from the PVWatts® calculator, eligibility assumptions were determined by judging the feasibility of solar on the rooftop based on the aerial imagery. I.e., if a facility was historic (such as a Town Hall), or the rooftop had irregularities, obstacles and slope type that would alter solar PV feasibility, judgement was used to determine a percentage from 0% (not eligible) to 50% (eligible), with these rooftop irregularities in mind.

The tool used an average of Mass CEC costs to establish a cost estimation. To estimate total implementation costs, the tool applied the following cost per unit assumption:

Description	Cost	Unit
PV	$3.11[16]	$/W

Cost estimates do not account for prevailing wage requirements in Massachusetts.

Energy Consumption Projections

After an ECM eligibility assumption for each building was established, the tool estimated the energy increases and/or decreases and costs associated with each ECM for each fuel type (electricity (kWh), natural gas (MMBTU), oil, (MMBTU), and propane (MMBTU)). These projections included the energy change over time for each Roadmap time period and cumulatively to demonstrate the impacts of ECM implementation through 20250. The tool also projected the emissions change over time, using the projected energy changes and fuel emission factors provided above, to demonstrate the emission reductions over time and by fuel type.

[14] Energy Home, DEP, Montgomery County, MD (montgomerycountymd.gov)
[15] PVWatts Calculator (nrel.gov)
[16] https://www.masscec.com/resources/commercial-solar-information-hub