Energy Committee Meeting Packet
February 24, 2025

Minutes 1/27/25

Energy Committee Minutes (01/27/2025)

Attendees

Co-Chair - Brian Boyle
Co-Chair - Bob Higgins-Steele
David Spencer - Member
Harry Irwin - Member
Chris Palmer - - Truro Climate Action Coordinator
Jarrod Cabral - DPW Director

Main Points of the Meeting (by Harry Irwin)

A - Chris Palmer just started working for the Town of Truro as the Climate Action Coordinator. He has a masters degree in Environmental Sustainability
B- Jarrod Cabral update.
-Jarrod set up a meeting with Cape Light Compact, Lisa of DOER and Chris to educate Chris on the grant submission process. Currently no update on the Climate Leader Status application.
-Jarrod has requested $200k for consultant on the plans to update the envelope and MEP equipment for the town buildings. All work should be designed with an eye on our decarbonization road map in coordination Mass Save 2013 guide to deep energy retrofit for builders. Jarred would prefer to have a committee for the selection of design candidates. The committee should include members from the Climate Action and Energy committee so they could have voice in the selection process.

-Solar Procurement - the Lease RPF is out. We will also ask for an estimate for Design, Construction, Permitting and Operation and Maintenance. RFP and construction estimates should be in around Feb 24th. Spec on the panels, converters & warrantee should be provided with each estimate. The interconnection can take between 1 and 5 years depending on who you talk to. CLC thinks they could expedite the connection to the lower end at 1 or 2 years.
C - Motion to appoint Bob Higgins-Steele as our liaison to the Climate Action Committee and Brian Boyle to the Ad Hoc Building Committee was approved unanimously.
D- DPW designers should consider embedded carbon life cycle.
E- MVP Grant requests to be submitted for 1) resilient hubs and micro grid and 2) undergrounding electric cables on beach points on 6A
F- There was a spirted discussion on the pros and cons of battery backup with Solar Panels vs. Propane or diesel emergency power back up.
F- Energy Committee and the Climate Action Committee will be presenting at the Select Board tomorrow. The committee should focus on next steps. The landfill is the highest priority.

Quick recap. (By AI)

Chris Palmer, the new Climate Action Coordinator, introduced himself and shared his background in environmental sustainability and climate change advocacy. The team discussed various topics including the status of solar panels at the transfer station, the upcoming $200,000 request for consulting and engineering services, the lease RFP for solar procurement, and the potential of solar energy for the town. They also discussed the town's power infrastructure, the need for a clear and concise presentation to the town council regarding the solar project at the transfer station, and the importance of focusing on the next steps for the climate action plan.

Next steps

• Brian and Bob to revise and shorten the presentation for the Select Board meeting, focusing on the landfill solar project and funding request.
• Brian to check with Town Hall about booking meeting rooms for Mondays for the next 3 months.
• Energy Committee members to review the Climate Action Plan draft and provide input on the municipal side before the next meeting.
• Chris to work with Jared on getting detailed information about the town's vehicle inventory and energy usage.
• Bob to send Chris the video about the regional microgrid involving Truro, Provincetown, and Wellfleet.
• Energy Committee to prepare two separate warrant articles for Town Meeting: one for funding the solar project and another for the revolving fund.

- Brian to ensure the next Energy Committee meeting is scheduled for Monday, February 17th.

Summary

New Climate Action Coordinator Introduced

Chris Palmer introduces himself as the new Climate Action Coordinator, having started the previous Tuesday. The Energy Committee meeting begins with Brian conducting a roll call and announcing the meeting details. Bob inquires about potential new members, noting that there is space for one more full member and one alternate. Harry confirms he has been sworn in as a full member. The committee briefly discusses the history of solar panels at the transfer station, including issues with the landfill cap and its certification process.

New Team Member and Project Updates

Chris, a new member of the team, shared his background in environmental sustainability and climate change advocacy. He moved to the US in 2017, lived in Portland for six years, and recently relocated to Truro with his family. Chris expressed his gratitude for the opportunity to join the team and his excitement to contribute to the community's climate initiatives. Jared provided an update on the team's activities, including a meeting with Cape Light Compact, the status of a grant application, and the upcoming execution of a contract with Brewster. Brian and Bob were present during the meeting, with Brian asking for clarification on the status of the contract with Brewster.

Consulting Services and Solar RFPs Discussed

Jared Cabral discussed the upcoming $200,000 request for consulting and engineering services for their facilities, aiming to bring on a consultant to assess their needs and develop a decarbonization plan. The request is part of the Capital Improvement Plan (CIP) for the upcoming town meeting in May. Bob suggested that the consultant should have a background in building science and architecture. Harry clarified that Building Science Inc. are better suited for assessing weaknesses and challenges in buildings, while larger firms are better for design plans. Bob also suggested that the consultant should be familiar with the "Deep Energy Retrofit for Builders" manual. Jared also discussed the lease RFP for solar procurement, which includes facilities, parking lots, the burn, transfer station landfill area, and the library. He mentioned that he has reached out to two solar providers for estimates on construction, design, and permitting costs for each location. The RFPs are due on February 24th. David Spencer asked about the reason for using an RFP instead of a request for bids, to which Jared clarified that it's a tabletop exercise and the solar providers will likely do the estimates for free.

Vertical Construction and Certification Requirements

In the meeting, the team discussed the requirements for vertical construction and the need for certification. They clarified that rooftop solar installations are considered part of vertical construction and require certification. The team also discussed the process for obtaining permits for landfill solar panel installations. There was a discussion about the potential delay in interconnection agreements, with estimates ranging from 1 to 5 years. The team agreed to measure twice and cut once to ensure they own the necessary rights for power transmission. They also considered reaching out to their counterpart at DPW Wellfleet to learn from their past mistakes. The team concluded that there should be no difference in the interconnection process whether they lease the site or operate it themselves.

Solar Energy Options and ROI Discussion

The team discussed the potential of solar energy for the town, focusing on the benefits and challenges of leasing versus owning solar panels. They agreed on the need for more accurate data on energy usage, particularly for vehicles, to better understand the demand for solar power. The team also discussed the potential impact of the current administration’s executive orders on the tax credits and grants for solar projects. They concluded that running the numbers for both leasing and owning options was essential to make an informed decision. The team also discussed the importance of considering long-term ROI and the potential for a positive outcome even without tax credits.

Power Infrastructure and Microgrids Discussion

The committee discusses the town's power infrastructure and potential improvements. Bob reports on two MVP grant applications: one for resilience hubs and microgrids, and another for undergrounding power lines and raising the elevation of Route 6A from Provincetown to Knowles Heights, potentially in collaboration with Provincetown. Brian and Bob explain the vulnerabilities of the current power system, which relies on a battery (BESS) in Provincetown, and emphasize the need for Truro to develop its own microgrids for better resilience. They also discuss Eversource's plans for grid modernization and smart switching to limit outages.

Emergency Power Backup and Climate Plan

In the meeting, Brian, Bob, David, Harry, and Chris discussed the town's emergency power backup system. They agreed that the current system, which relies on batteries, is not sufficient for extended power outages. David suggested that a diesel generator would be a more reliable solution. They also discussed the town's climate action plan, with Bob suggesting that the Energy Committee and the Climate Action Committee should review and provide input on the draft plan. Chris asked for clarification on the scope of the Energy Committee and the Climate Action Committee, which Brian and Bob explained as focusing on the

municipality itself and community outreach, respectively. They agreed to continue their work on the climate action plan and to discuss the select board meeting in their next meeting.

Focusing on Landfill Project Progress
Bob expressed his frustration over the lengthy process of getting to the current stage of the project, but also acknowledged the progress made with the town. David emphasized the importance of focusing on the next steps, particularly the decision on the landfill, and keeping the message clear and uncluttered. Brian agreed, highlighting that their initiatives align with the town's objectives, particularly in terms of climate crisis, recurrent revenue generation, and strategic land use. The team also discussed the presentation to be made to the select board, with David suggesting a more direct approach to convey their main point. The team agreed to focus on the need for the town's support to move forward with the landfill project.

Solar Project Presentation and Funding
The team discussed the need for a clear and concise presentation to the town council regarding the solar project at the transfer station. They agreed to focus on the project's funding and construction, with the possibility of discussing a revolving energy fund in a separate meeting. The team also decided to schedule regular meetings, with the next one set for the 17th of the month. They acknowledged the importance of presenting a clear and compelling case to the town council to secure funding for the solar project.

Discuss Revising municipal Road map

Green School Works

How to Participate

Green School Works, in partnership with Eversource, National Grid, and the Department of Energy Resources, plans to support comprehensive upgrades to transform schools to low- or zero-net energy facilities that provide high indoor environmental quality for students and staff. We expect that applicants receiving Massachusetts School Building Authority (MSBA) funding for heat pump conversions will be the most competitive applicants to receive funding for these larger-scale transformations.

Therefore, potential applicants for Green School Works grant funding are **strongly encouraged** to submit a statement of interest (SOI) to be considered for competitive grant funding through the MSBA Accelerated Repair Program for heat pump conversions by **Friday, March 21, 2025**. If you have questions for the MSBA, please visit the MSBA SOI page and fill out the contact form linked at the bottom.

Additional information about how to apply for MassCEC's technical assistance and grants will be added to this page in the future.

Truro Municipal Decarbonization Roadmap

12 December 2024

Massachusetts Department of Energy Resources

GREEN COMMUNITIES
Massachusetts
DEPARTMENT OF ENERGY RESOURCES

ICF

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Purpose and Acknowledgements

Truro is committed to taking action to mitigate climate change. Truro aims to lead by example and reduce emissions from Truro's facilities, equipment, and operations to support climate and sustainability goals and make operations more efficient. As a participant in the Massachusetts Green Communities program, Truro 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. This Decarbonization Roadmap provides a framework for Truro to further these efforts and continue implementing clean energy strategies to eliminate the use of fossil fuels on-site by 2050.

While Truro's goal is to decarbonize municipal facilities by 2050, not all buildings and facilities are included in this roadmap. 85.9% 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 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 the purpose of estimating the municipal emissions over time, these buildings and facilities will be assumed to uniformly reduce emissions over the twenty-six years covered in the roadmap.

Acknowledgements

List of Contributors

Truro

Jarrod Cabral

Other Partners

Lisa Sullivan (DOER)

Julian Joffe (RISE)

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Executive Summary

This Decarbonization Roadmap[1] describes Truro's 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 2050. This Roadmap considers how emissions are generated throughout Truro's facilities and vehicles and the potential costs associated with the ECMs necessary to achieve decarbonization by the target year. Truro 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 Truro

Town should include details and context that will inform the recommendations (populations, scope of facilities and services provided, history of green community participation, existing energy reduction policies and systems that have been implemented).

Summary of Municipal Building Portfolio

Truro manages 14 facilities and spends $150,000 per year on energy costs for these facilities. These facilities are a critical part of Truro's operations and services and are directly utilized by the community, including the central school, community centers, and public safety building.

The Department of Public Works (DPW) is the lead implementer of energy management strategies and programs impacting building operations and maintenance. The DPW works closely with other Departments (and appropriate Committees) to assess building needs, identify opportunities for clean energy improvements, and budget for or identify additional funding opportunities to implement facility and fleet upgrades.

Facility Name
Central School
Public Safety
Public Library
Town Hall
Community Center
Transfer Station
Recreational Field House
Beach Office

Summary of Municipal Emissions

In FY22 Truro's operation of municipal buildings, open spaces, vehicles, and traffic lights was responsible for 654.1 MTOCO2e. Municipal buildings contributed heavily to these emissions. Table 1 summarizes Truro's town-wide emissions.

Municipal buildings in Truro rely on a mix of electricity, oil, and propane for fuel. The use of these fuels results in carbon dioxide emissions. Building specific emissions range widely. Among the modeled buildings in this roadmap, the highest emitting building was responsible for 137.2 MTCO2e in FY22 while the lowest emitting building was responsible for 1.8 MTCO2e. The average emissions in FY22 from attributed to buildings included in this roadmap was 26.9 MTCO2e.

[1] The decarbonization roadmap is distinct from a community's ERP in that it lays out the path to municipal decarbonization by 2050, 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.

Table 1. Summary of Metric Tons of CO2 equivalent emissions (MTCO2e)

Emission Category	Emissions in Baseline Year (MTCO2e)	Ownership
Buildings	377.0	Municipality
Open Space	-	Municipality
Vehicle	276.0	Municipality
Streetlights	1.2	Municipality

Source: MEI

Summary of Emissions Reduction Potential

Truro's baseline municipal building emission portfolio presents strong emission reduction potential over the next 25 years. Table 2 summarizes the timeline of Truro's municipal emission reduction. The majority of Truro municipal building emissions are generated from electricity use. Without any ECMs, these emissions will decrease as the electrical grid transitions to cleaner generation sources. Truro's building portfolio is also poised to reduce both emissions and overall energy consumption by implementing ECMs that will increase the energy efficiency of municipal buildings. This roadmap proposes ECMs that will reduce Truro's EUI by 97% by 2050. Further major equipment replacements will reduce Truro's municipal building emissions by 97% by 2050.

Table 2. Summary of Municipal Emissions Reductions

Targets	2022	2027	2030	2040	2050
Reduce emissions from onsite fossil fuels via electrification	**0%**	**-11%**	**-62%**	**-100%**	**-100%**
Zero emission vehicles (ZEVs) in light-duty fleet adoption (% of fleet)	**0%**	**10%**	**50%**	**80%**	**100%**
Zero emission vehicles (ZEVs) in medium-/heavy-duty fleet adoption (% of fleet)	**0%**	**10%**	**50%**	**80%**	**100%**
Energy Use Intensity reduction (deep energy retrofits/retro commissioning)	**EUI****	**-13%**	**-56%**	**-89%**	**-97%**
Total Emissions Reduction Goals (% of 2022 emissions)	**0%**	**13%**	**55%**	**89%**	**97%**

Municipal Building Portfolio

The Truro Municipal Decarbonization Roadmap includes eight of the fourteen municipal buildings comprising 90.4% of municipal building emissions: Truro Central School, Public Safety PFR, Library, Town Hall, Community Center, Transfer Station, Beach Office, and Field House.

Data sources used to develop baseline building emissions and characteristics include MassEnergyInsight (MEI), and data provided by Truro on each of the included facilities.

Municipal Emissions Baseline

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.

As of the completion of this roadmap, MA EEA is finalizing electricity emission factors for 2022. This roadmap uses 0.0002345 MTCO2e/kWh, and MEI, as of October 2024, uses 0.000243 MTCO2e/kWh. As a result, minor differences in baseline emissions may exist when comparing the baselines here and in MEI. DOER is aware of this difference and has approved the distinct emission factors for this roadmap.

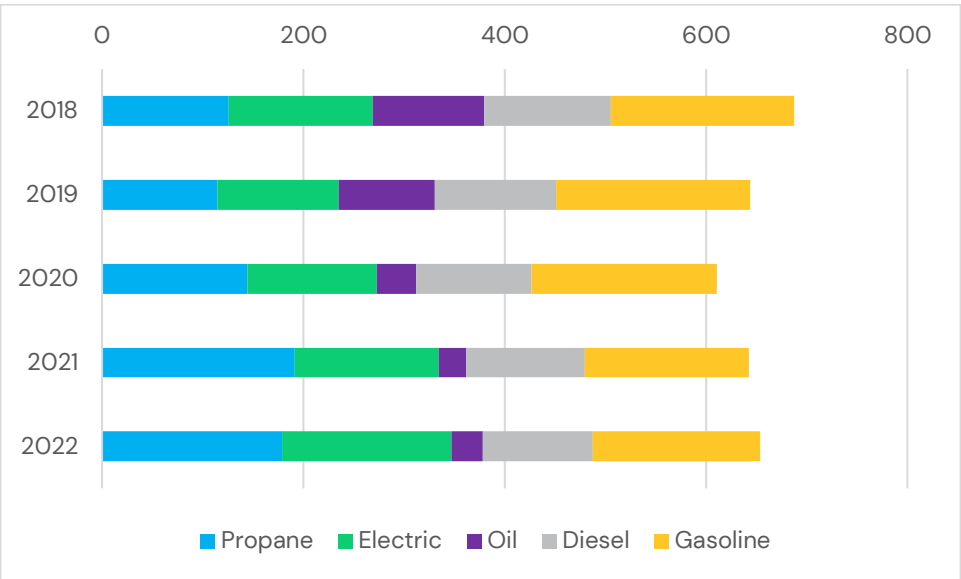
Identification of Inventory Tool

The fuel consumption and emission baseline used for the Truro buildings is MEI. Emission factors utilized by MEI are reported in Appendix D.

Municipal Emissions Over Time

As shown in Figure 1, Truro's municipal emissions have been decreasing over time, with lower consumption of all on-site fossil fuels from FY18 – FY22. As a Green Community, Truro has been continually engaging in ECMs and EUI reduction strategies.

Figure 1. Truro Municipal Emissions FY18-FY22 (MTCO2e)



During the baseline year of FY2022, Truro's emissions were comprised of 27.3% propane, 25.7% electricity, 25.4% gasoline, 16.8% diesel, and 5.7% oil.

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 fourteen municipal buildings included in the decarbonization roadmap. For each building, there is a brief narrative description of the building uses including regular and outlier cases, a brief overview of building characteristics[2], a summary of fuel usage by emissions in the baseline year (FY2022), and a summary of implemented ECMs.

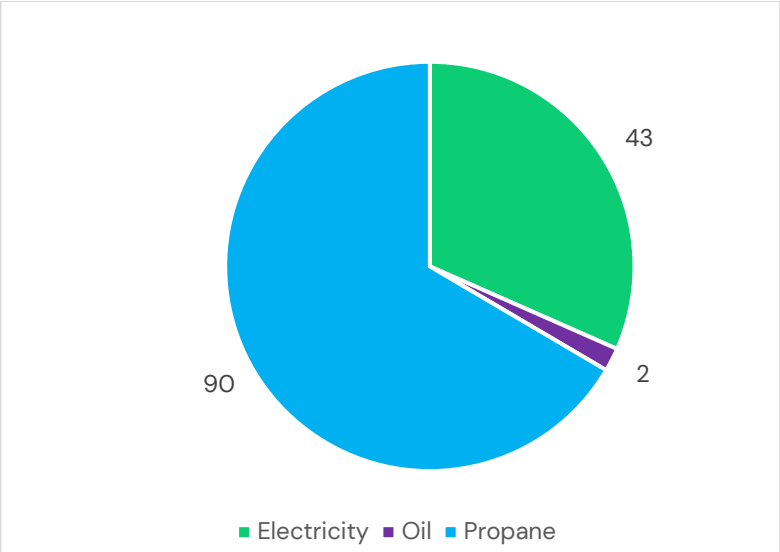
Truro Central School

The Truro Central School is the largest single source of municipal GHG emissions in the town. The school was built in 1938 and there was a significant renovation in 1990. It has a recent solar array that generates a portion of electricity usage annually, and the overall building condition is okay. The primary fuel types used by the Central School are propane electricity, and oil.

Building Characteristics	
Year Built	1938, 1990 addition
Square Footage	33,521
Future Plans	Keep
GHG (FY22)	137.2 MTCO2e
EUI (FY22)	61.44 kBtu/sf
Building Condition	Fair

The fuel types used at the Truro Central School during FY2022 are shown in Figure 2.

Figure 2. Truro Central School Emission by fuel type (FY2022)



[2] 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)

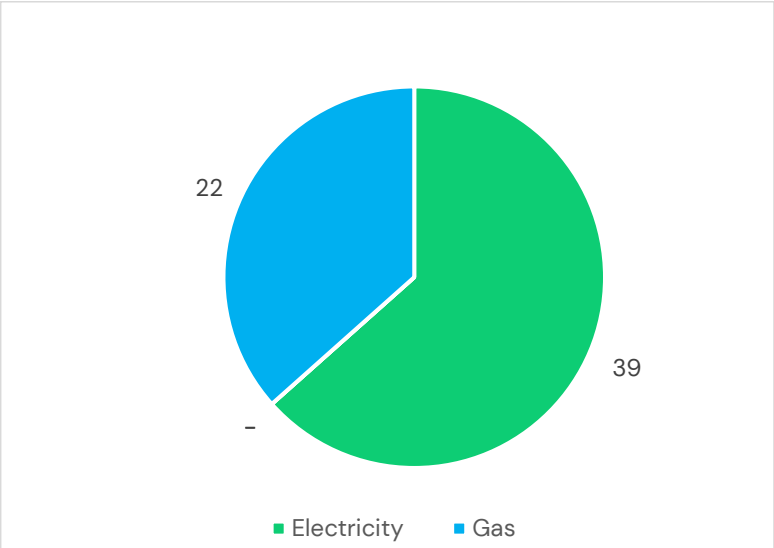
Public Safety PFR

The Public Safety PFR is a critical municipal facility as it serves as the headquarters of the police, fire, rescue, and emergency management departments. The primary fuel types used by the Public Safety PFR are electricity and propane gas.

Building Characteristics	
Year Built	1996
Square Footage	10,310
Future Plans	Keep
GHG (FY22)	62.5 MTCO2e
EUI (FY22)	88.91 kBtu/sf
Building Condition	Good

The fuel types used at the Public Safety PFR during FY2022 are shown in Figure 2.

Figure 3. Truro Public Safety PFR Emission by fuel type (FY2022)



Library

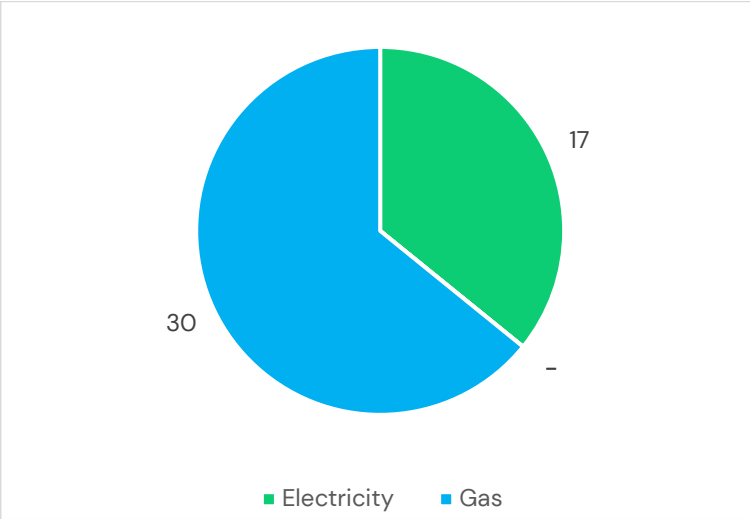
The Truro Public Library was constructed in 1998 and serves as a central community hub and houses a community meeting place. The primary fuel types used by the Library are propane gas and electricity.

Building Characteristics	
Year Built	1998
Square Footage	11,275
Future Plans	Keep
GHG (FY22)	48 MTCO2e
EUI (FY22)	64.27 kBtu/sf

Building Condition	Good

The fuel types used at the Library during FY2022 are shown in Figure 2.

Figure 4. Public Library Emission by fuel type (FY2022)



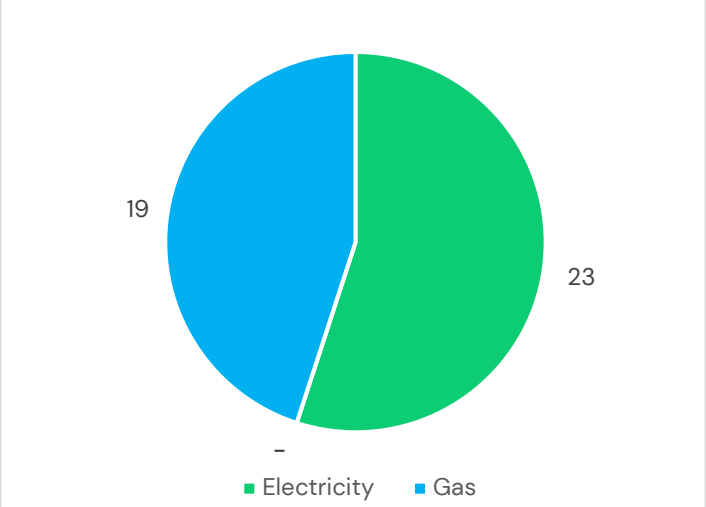
Town Hall

The Town Hall is the central location for multiple local government departments in the town as well as the meeting place for several organizations. The building underwent a significant change in 2004 when it was moved from the original footprint so a basement could be constructed. The primary fuel types used at Town Hall are electricity and propane gas.

Building Characteristics	
Year Built	1848
Square Footage	10,074
Future Plans	Keep
GHG (FY22)	42.6 MTCO2e
EUI (FY22)	62.62 kBtu/sf
Building Condition	Fair

The fuel types used at the Truro Town Hall during FY2022 are shown in Figure 2.

Figure 5. Truro Town Hall Emission by fuel type (FY2022)



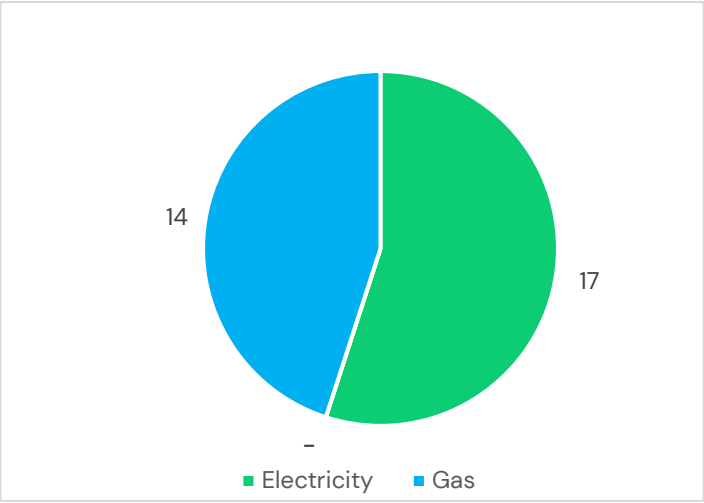
Community Center

The Community Center is a central hub for the community and recreation department, and senior center. The primary fuel types used at the Community Center are electricity and propane.

Building Characteristics	
Year Built	2007
Square Footage	9,245
Future Plans	Keep
GHG (FY22)	31.5 MTCO2e
EUI (FY22)	50.37 kBtu/sf
Building Condition	Good

The fuel types used at the Community Center during FY2022 are shown in Figure 2.

Figure 6. Community Center Emission by fuel type (FY2022)



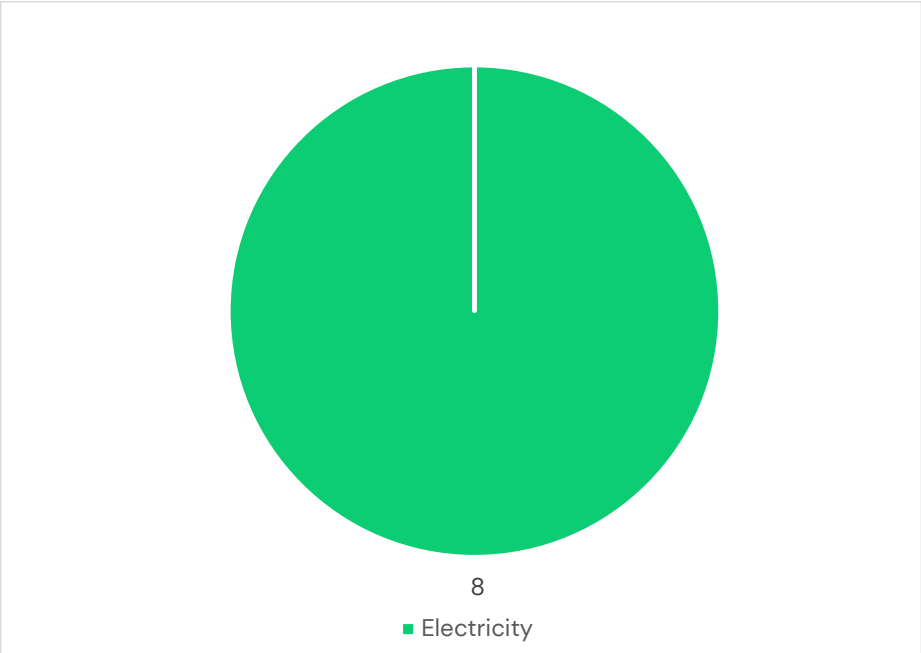
Transfer Station

The Transfer Station facility is a small office building and control space used to manage the transfer station activities. The primary fuel type used at the transfer station is electricity.

Building Characteristics	
Year Built	2006
Square Footage	560
Future Plans	Keep
GHG (FY22)	8.7 MTCO2e
EUI (FY22)	274.69 kBtu/sf
Building Condition	Good

The fuel types used at the Transfer Station during FY2022 are shown in Figure 2.

Figure 7. Transfer Station Emission by fuel type (FY2022)



Beach Office

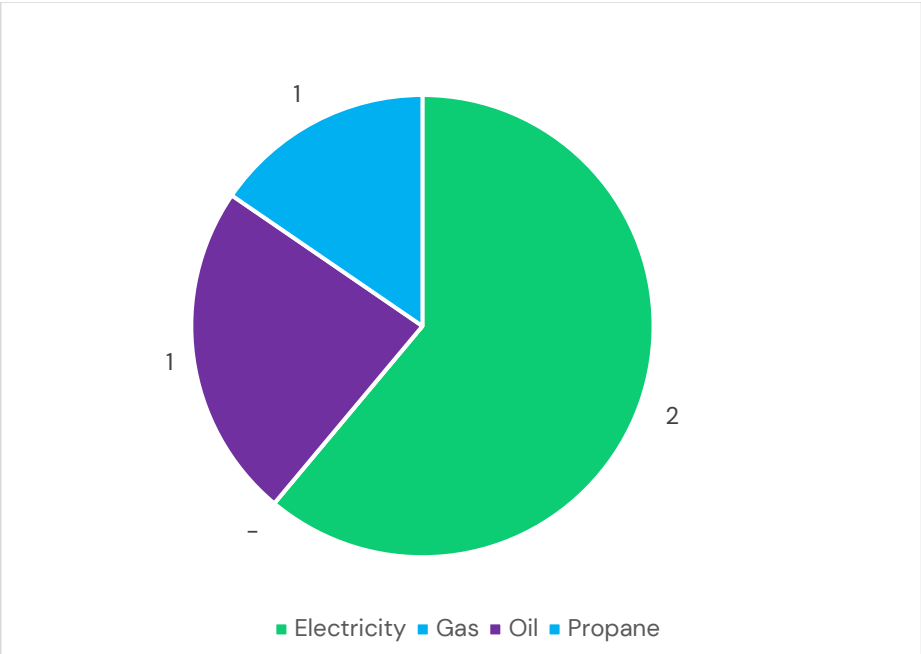
The Beach Office is a seasonal facility used by the recreation and beach department for administrative activities. The primary fuel types used at the beach office are electricity and propane. While the core equipment at the Beach Office are electric, there is a propane generator that is used for backup power.

Building Characteristics	
Year Built	1961
Square Footage	1,000

Future Plans	Keep
GHG (FY22)	3.6 MTCO2e
EUI (FY22)	51.6 kBtu/sf
Building Condition	Good

The fuel types used at the Beach Office during FY2022 are shown in Figure 2.

Figure 8. Beach Office Emission by fuel type (FY2022)



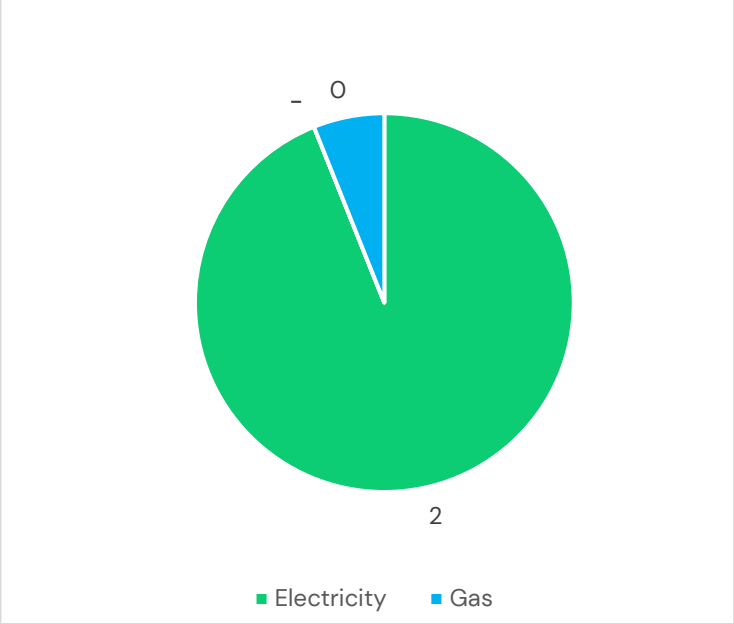
Field House

The Field House is a small office and storage space for the recreation department. The primary fuel types used at the Field house are electricity and propane gas.

Building Characteristics	
Year Built	2003
Square Footage	560
Future Plans	Keep
GHG (FY22)	1.8 MTCO2e
EUI (FY22)	46.2 kBtu/sf
Building Condition	Good

The fuel types used at the DPW Office during FY2022 are shown in Figure 2.

Figure 9. Field House Emission by fuel type (FY2022)



Other Buildings

As mentioned at the beginning of the Municipal Building Portfolio section, this roadmap includes the great majority of Truro'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 less than that presented for the preceding buildings and facilities.

Table 3. Other Building Emission Baselines

Building Name	Square Footage	Plans	GHG (FY22)	EUI (FY22)	Building Env
DPW Sweeper	810	Keep	5.3	88.4	Excellent
DPW Carpenter Shop	816	Keep	3.7	61.2	Good
DPW Office	492	Keep	9.9	287.7	Fair
DPW Garage	2,560	Keep	18.8	100.1	Fair
Harbormaster	252	Keep	2.3	125.9	Fair
Swap Shop	960	Keep	59	14.2	Fair

Decarbonization Roadmap Narrative

Truro's building portfolio presents multiple opportunities to implement decarbonization strategies and meet Truro's decarbonization goals. The following section describes the key strategies that Truro can implement at their facilities to eliminate onsite fossil fuel use by 2050 and make incremental emissions reductions beginning in the near term. While this Roadmap identifies building-specific strategies for Truro 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 Truro'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 of decarbonization strategies to be implemented by the community, as well as facility specific recommendations. 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 and ensure 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).

Within the facility level recommendation section below, ECMs are broken down into a brief description of the ECM that could be implemented, the proposed timeline for implementation, the estimated emission reduction generated by the ECM, and the rough estimate of cost. Costs are broken down into four buckets (<$10,000, $10,000 - $50,000, $50,000 - $100,000, $100,000 - $250,000, and >$250,000). The description of major triggering events outlines those ECMs identified as falling into the largest cost bucket (>$250,000).

As Truro 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, Truro will adopt them and add that transition to their decarbonization roadmap.

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 the majority of 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 completely air sealing 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 weatherstripping windows and door frames and air sealing and improving insulation by utilizing R-49 if some insulation exists, or R-60 if there is none. ENERGY STAR provides a detailed list of insulation best practices, as well as incentive information.

HVAC Electrification and Controls Retrofit[3]: 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 aren't 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. For facilities with relatively flat or appropriately aspected roofs, solar arrays can be a beneficial investment.

Summary

Overview of Goals for implementation to 2027 and 2030

Truro has identified the primary goals of their roadmap through 2030 to be the rightsizing of building energy use. They are also examining the existing fossil fuel uses and identifying replacement equipment when end-of-life is reached.

Overview of Goals for calendar years 2040 and 2050

After decarbonizing all of the municipal facilities by 2030, the remaining facilities not covered in the inventory will be decarbonized over the following decade. Additional renewable energy development may be considered as a further reduction in energy use intensity at facility sites where it is feasible. Several of Truro's facilities are designated as emergency shelters and require 72 hours of self-sufficient power generation. At this time, battery storage alternatives to generators are not financially viable, however as options enter the market and prices decrease, Truro will re-evaluate the electrification of emergency shelters.

[3] *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.*

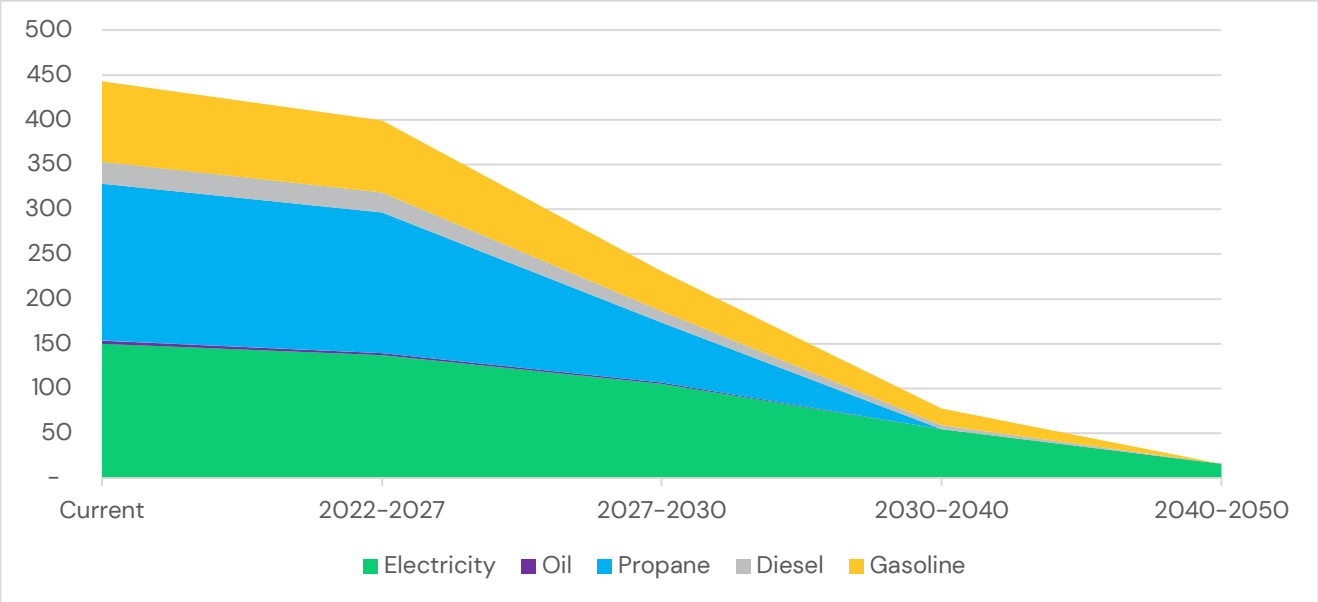
Areas of highest emissions and greatest opportunity for impact

Due to Truro's ongoing commitment to reducing their climate impact, and efforts to reduce energy consumption, many of the easiest opportunities for emissions reduction have been achieved, such as LED replacements. The Central School, as the largest source of emissions, is the primary focus of the town's decarbonization efforts.

Achieving Elimination of Onsite Fossil Fuel Use by 2050

Through the recommended actions at the facility level discussed below, Truro will achieve decarbonization of their facilities by 2050. As technical and financial limitations allow, recommendations can be implemented sooner, which would result in decarbonization well before 2050 if fossil fuel equipment is targeted for replacement. In addition to the main recommendations and equipment replacements, ongoing energy audits maintenance is a core piece of the decarbonization roadmap, as it allows Truro to better monitor its building portfolio and identify replacement needs and upcoming maintenance.

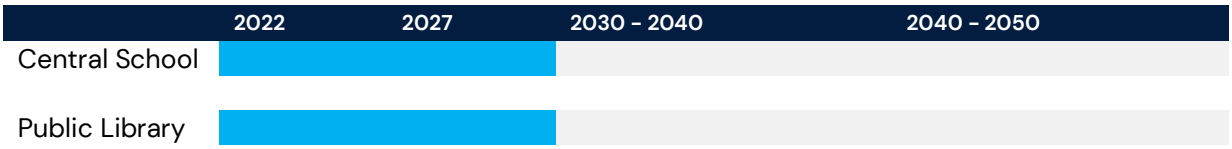
Figure 10. Truro Emissions Forecast 2022 Through 2050

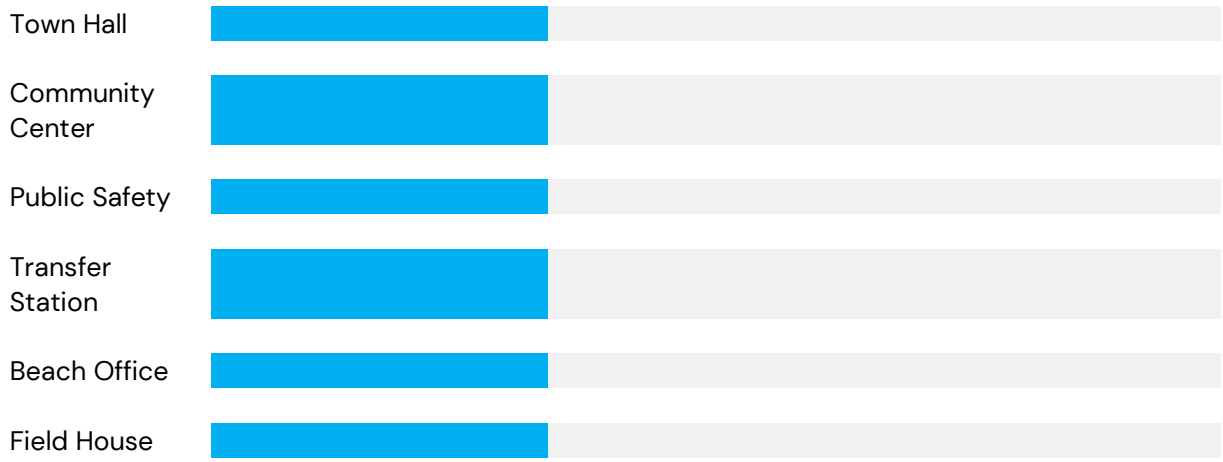


Description of Major Trigger Events to Achieve Onsite Fossil Fuel Elimination

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 a broad period of time to eliminate the occurrence of overlapping projects which may increase the risk of deviating from the roadmap. While events may appear to overlap in later years, note that the trigger event timeline shifts to 5-year increments following 2030.

Figure 11. Trigger Event Timeline





Central School

The Central School requires all of the major trigger event capital projects proposed in this Roadmap. First from 2025-2030 the Central School requires insulation and weatherization ECMs to right-size energy use. Second, the Roadmap proposes complete HVAC and water heating electrification of the Central School by 2030.

Public Library

The Public Library requires all of the major trigger event capital projects proposed in this Roadmap. The Public Library should undergo right-sizing through insulation and weatherization ECMs..

Town Hall

The Town Hall requires all of the major trigger event capital projects proposed in this Roadmap. First from 2025-2030 the Town Hall should add additional insulation and pump motors. Second, the Roadmap proposes complete HVAC and water heading electrification of the Town Hall by 2030.

Community Center

The Community Center requires all of the major trigger event capital projects proposed in this Roadmap. First from 2025-2030 the Community Center should add additional insulation and weatherization. Second, the Roadmap proposes complete HVAC and water heading electrification of the Community Center by 2030.

Public Safety PFR

The Public Safety PFR requires all of the major trigger event capital projects proposed in this Roadmap. The Roadmap proposes complete HVAC and water heading electrification of the Public Safety PFR by 2030.

Transfer Station

The Transfer Station is already an electrified facility, further EUI reduction through additional ECM measures may be useful, but the facility will decarbonize as the grid cleans over time.

Beach Office

The Beach Office's only fossil fuel use is the back-up generator. As a result, when distributed energy solutions are feasible, the backup will be electrified without compromising the facilities functions.

Field House

The Field House requires all of the major trigger event capital projects proposed in this Roadmap. First from 2025-2030 the Field House should convert the lighting to LED. Second, the Roadmap proposes complete HVAC and water heading electrification of the Field House by 2030.

Facility Level Recommendations to Achieve Onsite Fossil Fuel Elimination

This section lays out baseline fuel consumption at a facility level for each of the eight 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[4], a summary of fuel usage by emissions in the baseline year (FY2022), and a summary of implemented ECMs.

[4] 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)

Truro Central School

As noted in the baseline inventory, the Truro Central School utilizes primarily propane and electric in the baseline year of FY2022.

Table 4. Truro Central School Decarbonization Plan

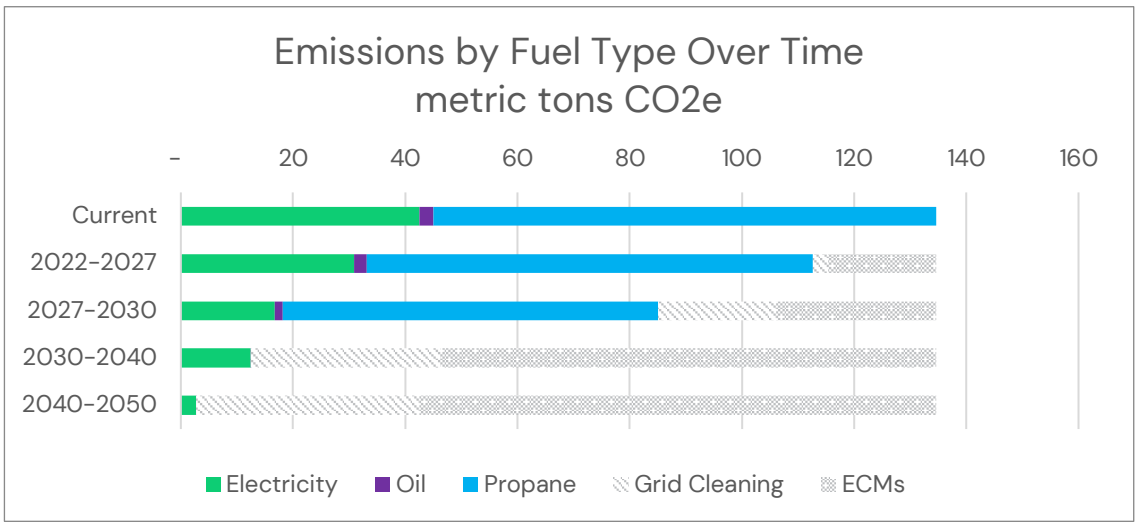
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2026	Lighting	$$$	8.2
FY2027	Weatherization	$$$	11.1
FY2028	Insulation	$$$$$	12.3
FY2029	Building Controls and HVAC Electrification	$$$$$	62.8

Table 5. Truro Central School ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Oil Decrease	Propane Decrease	Timing
Lighting	8.2				2026
Weatherization	0.7		0.3	10.1	2027
Insulation			0.7	12.6	2028
Building Controls and HVAC Electrification		5.7	1.5	66.9	2029

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Truro Central School are described in Figure 12. Some anticipated challenges include the fact that as a school, retrofits and ECM projects require additional logistics support to plan around academic calendars.

Figure 12. Estimated Future Building Emissions based on the Building Plan



Public Safety PFR

As noted in the baseline inventory, the Truro Public Safety PFR utilizes propane and electricity in the baseline year of FY2022.

Table 6. Truro Public Safety PFR Decarbonization Plan

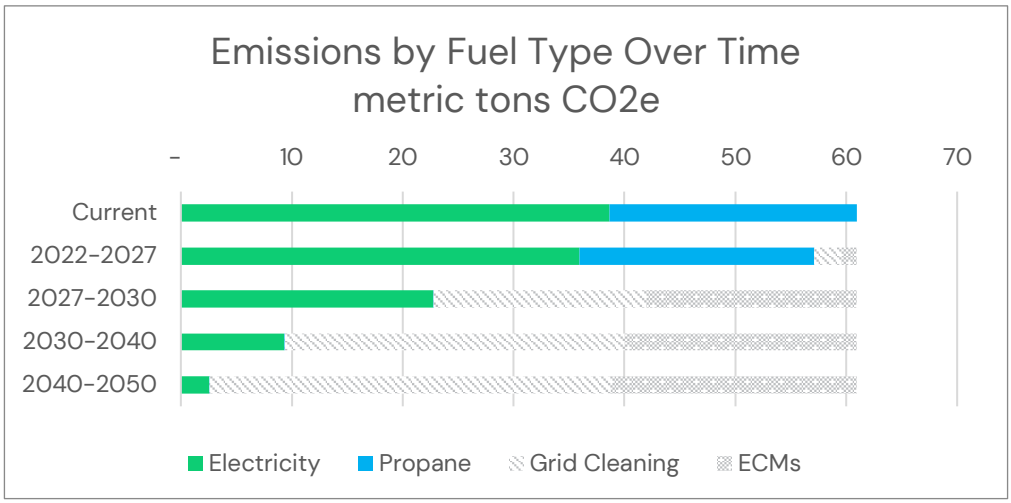
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2025	Weatherization	$$$	1.3
FY2027	Insulation	$$$	2.9
FY2030	Building Controls and HVAC Electrification	$$$$	14.7
FY2040	Water Heating Electrification	$$	0.3

Table 7. Truro Public Safety PFR ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Propane Decrease	Timing
Weatherization	0.2		1.1	2027
Insulation			2.9	2027
Building Controls and HVAC Electrification		3.3	18.0	2028
Water Heating Electrification		0.1	0.2	2028

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Truro Public Safety PFR are described in Figure 13. Some anticipated challenges are anticipated to be the critical functions of the facility, and ensuring that those services are not disrupted during the ECM projects.

Figure 13. Estimated Future Building Emissions based on the Building Plan



Library

As noted in the baseline inventory, the Library utilizes electric and propane in the baseline year of FY2022.

Table 8. Truro Public Library Decarbonization Plan

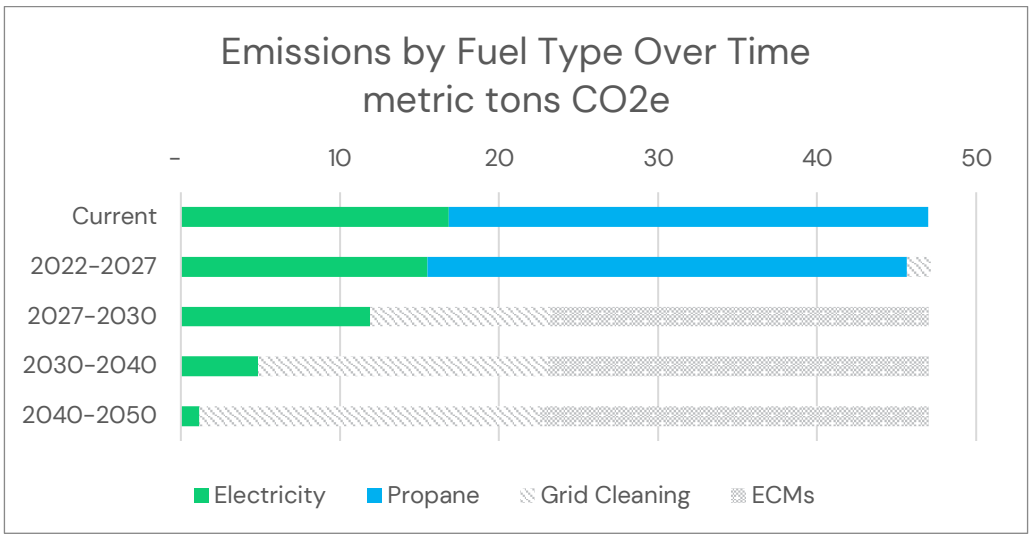
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2025	Weatherization	$	0.3
FY2027	Insulation	$$$$	7.9
FY2030	Building Controls and HVAC Electrification	$$$$$	18.2
FY2040	Water Heating Electrification	$$$	0.5

Table 9. Truro Public Library ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Propane Decrease	Timing
Weatherization	0.3			2025
Insulation	0.2		7.7	2026
Building Controls and HVAC Electrification		3.6	21.8	2026
Water Heating Electrification		0.1	0.6	2026

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Public Library are described in **Error! Reference source not found.** Some anticipated challenges for the Library include ensuring continued access to services during project periods.

Figure 14. Estimated Future Building Emissions based on the Building Plan



Town Hall

As noted in the baseline inventory, the Town Hall utilizes electric and propane in the baseline year of FY2022.

Table 10. Truro Town Hall Decarbonization Plan

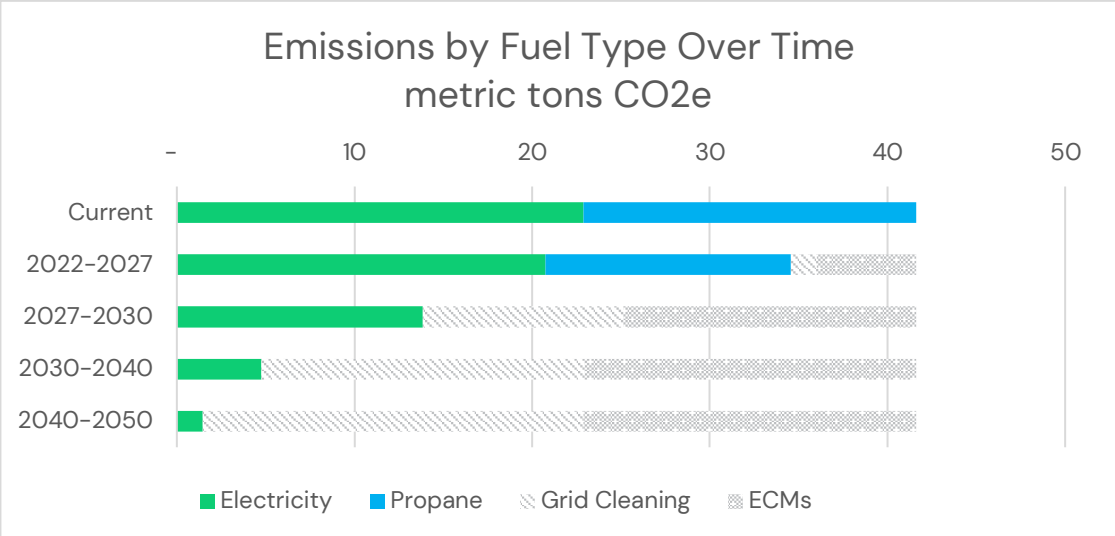
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2027	Insulation	$$$$	5.6
FY2030	Building Controls and HVAC Electrification	$$$$	10.7
FY2040	Water Heating Electrification	$$$	0.5

Table 11. Truro Town Hall ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Propane Decrease	Timing
Insulation	0.7		4.9	2027
Building Controls and HVAC Electrification		2.5	13.2	2027
Water Heating Electrification		0.1	0.6	2027

By implementing the proposed decarbonization plan in Table 10, the projected building emissions for the Truro Town Hall are described in **Error! Reference source not found.** Some anticipated challenges for the Truro Town Hall include the historic nature of the building which adds complexity and cost to retrofitting and renovation projects.

Figure 15. Estimated Future Building Emissions based on the Building Plan



Community Center

As noted in the baseline inventory, the Community Center utilizes electric and propane in the baseline.

Table 12. Truro Community Center Decarbonization Plan

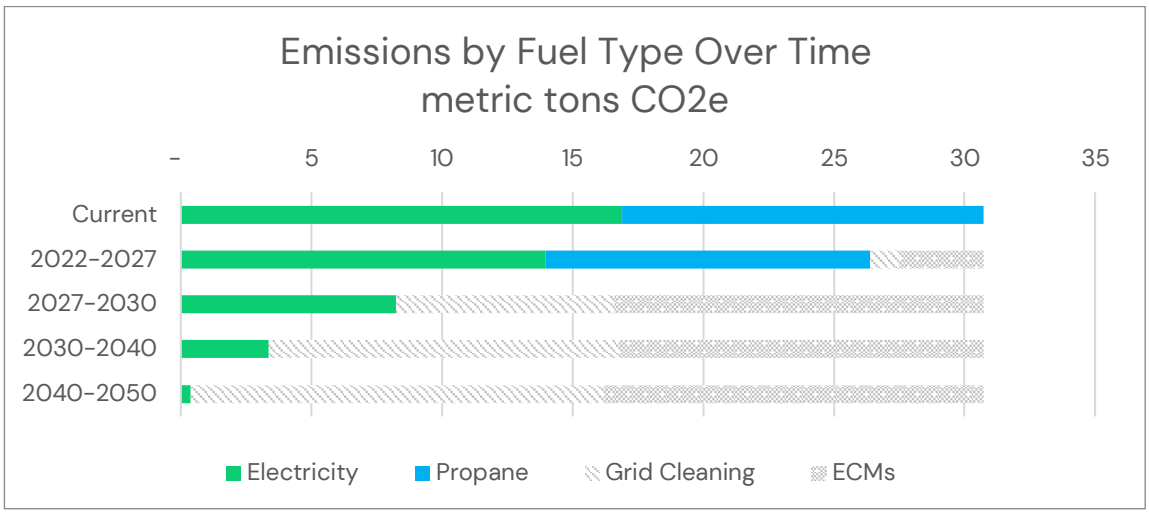
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2025	Weatherization	$$$	1.9
FY2027	Insulation	$$$$$	4.2
FY2030	Building Controls and HVAC Electrification	$$$$$	7.4
FY2040	Water Heating Electrification	$$$	0.2

Table 13. Truro Community Center ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Propane Decrease	Timing
Weatherization	0.5		1.4	2029
Insulation	0.7		3.5	2029
Building Controls and HVAC Electrification		1.3	8.7	2030
Water Heating Electrification		0.1	0.3	2030

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Truro Community Center are described in Figure 16. Some anticipated challenges are the continued operation and service of the facility during project periods.

Figure 16. Estimated Future Building Emissions based on the Building Plan



Transfer Station

As noted in the baseline inventory, the Transfer Station utilizes primarily electric, with some propane in the baseline year of FY2022.

Table 14. Truro Transfer Station Decarbonization Plan

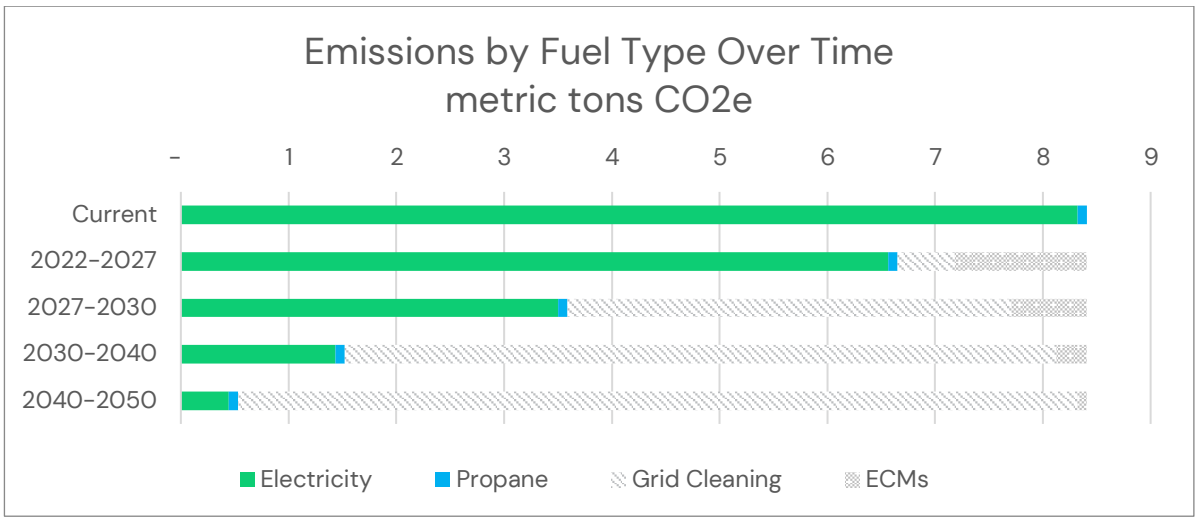
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2025	**Lighting**	$	1.2
FY2025	**Insulation**	$	0.1

Table 15. Truro Transfer Station ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Gas Decrease	Timing
Lighting	1.2			2025
Insulation	0.1			2025

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Truro Transfer Station are described in Figure 17.

Figure 17. Estimated Future Building Emissions based on the Building Plan



Beach Office

As noted in the baseline inventory, the Transfer Station utilizes electric, propane and oil for backup HVAC and generators in the baseline year of FY2022.

Table 16. Truro Beach Office Decarbonization Plan

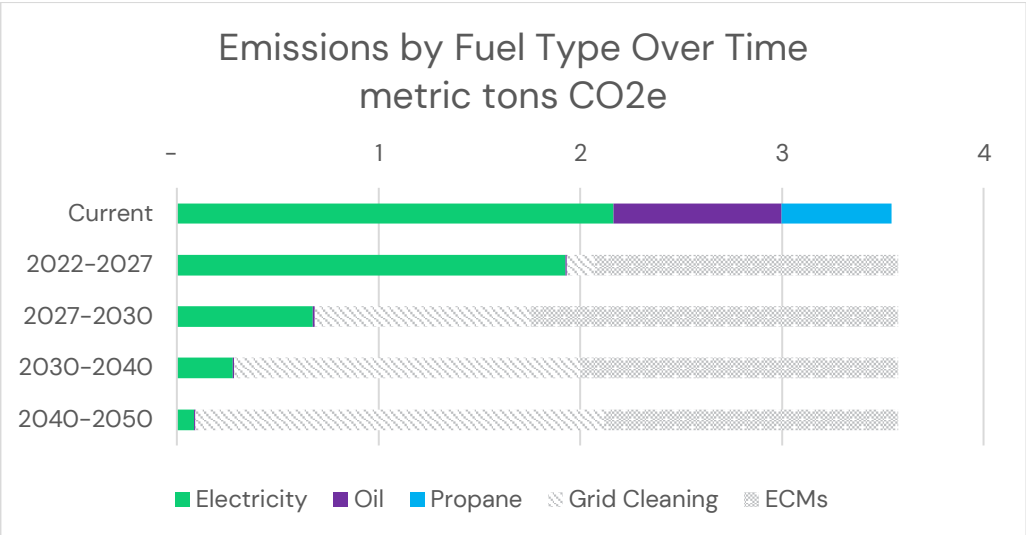
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2025	Lighting	$	5.3
FY2025	Weatherization	$	9.3
FY2026	Insulation	$$	25.7

Table 17. Truro Beach Office ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Oil Decrease	Propane Decrease	Timing
Lighting	0.1				2025
Weatherization	0.1		0.8	0.6	2025
Insulation	0.1				2026

By implementing the proposed decarbonization plan in Table 4, the projected building emissions for the Beach Office are described in **Error! Reference source not found.**

Figure 18. Estimated Future Building Emissions based on the Building Plan



Field House

As noted in the baseline inventory, the Transfer Station utilizes electric in the baseline year of FY2022.

Table 18. Truro Recreation Field House Decarbonization Plan

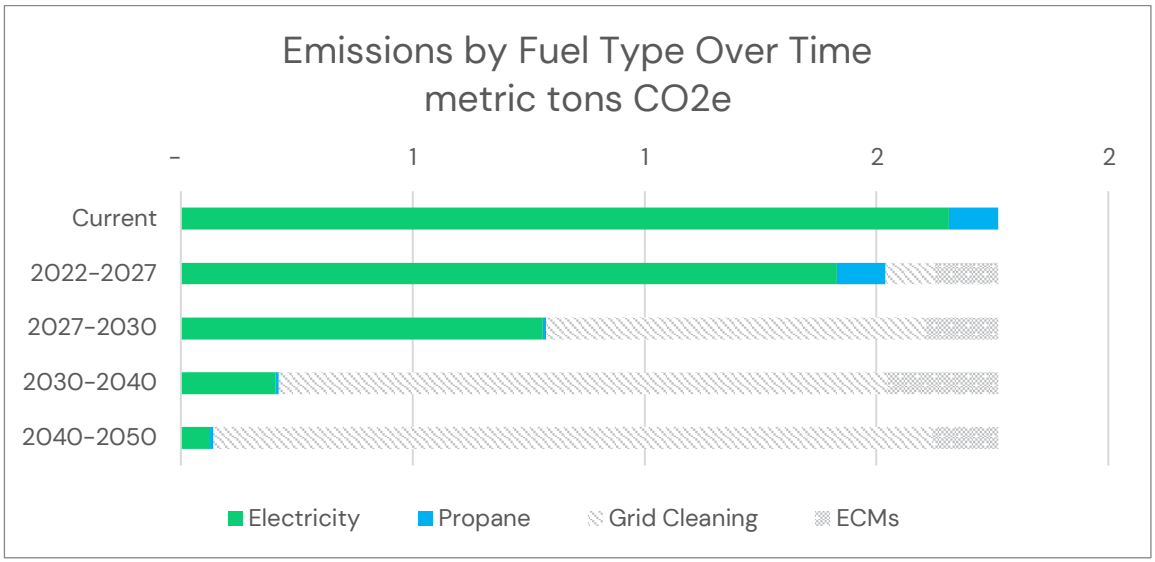
Planned	Proposed Strategy	Budget	FY22 vs FY50 MtCO2e
FY2026	Lighting	$	0.1
FY2025	Weatherization	$	0.1
FY2026	Building Controls and HVAC Electrification	$$$	0.1

Table 19. Truro Recreation Field House ECM Emission Reduction Forecast (MCTO2e)

ECM	Electricity Decrease	Electricity Increase	Gas Decrease	Timing
Weatherization	0.1			2025
Weatherization	0.1		0.1	2025
Building Controls and HVAC Electrification		0.0	0.1	2026

By implementing the proposed decarbonization plan in Table 18, the projected building emissions for the Field House are described in **Error! Reference source not found.**

Figure 19. Estimated Future Building Emissions based on the Building Plan



Other Buildings

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, resulting in decarbonization by 2050. For each of the facilities, identifying gaps in weatherization and the envelope are key to reducing the overall energy use of the facility prior to investing in expensive equipment replacements that electricity these facilities.

Vehicles

In FY2022, the municipal fleet of Truro generated a significant proportion of overall municipal emissions.

Light-Duty Vehicles

Within the municipal fleet of Truro, 38% is comprised of light-duty vehicles (17 vehicles). Truro 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 Truro's baseline municipal building emission portfolio presents strong emission reduction potential over the next 25 years. Table 2 summarizes the timeline of Truro's municipal emission reduction. The majority of Truro municipal building emissions are generated from electricity use. Without any ECMs, these emissions will decrease as the electrical grid transitions to cleaner generation sources. Truro's building portfolio is also poised to reduce both emissions and overall energy consumption by implementing ECMs that will increase the energy efficiency of municipal buildings. This roadmap proposes ECMs that will reduce Truro's EUI by 97% by 2050. Further major equipment replacements will reduce Truro's municipal building emissions by 97% by 2050.

Table 2. Summary of Municipal Emissions Reductions.

Medium-Duty Vehicles

Within the municipal fleet of Truro, 24% is comprised of medium-duty vehicles (11 vehicles). Truro 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 Truro's baseline municipal building emission portfolio presents strong emission reduction potential over the next 25 years. Table 2 summarizes the timeline of Truro's municipal emission reduction. The majority of Truro municipal building emissions are generated from electricity use. Without any ECMs, these emissions will decrease as the electrical grid transitions to cleaner generation sources. Truro's building portfolio is also poised to reduce both emissions and overall energy consumption by implementing ECMs that will increase the energy efficiency of municipal buildings. This roadmap proposes ECMs that will reduce Truro's EUI by 97% by 2050. Further major equipment replacements will reduce Truro's municipal building emissions by 97% by 2050.

Table 2. Summary of Municipal Emissions Reductions.

Heavy-Duty Vehicles

Within the municipal fleet of Truro, 38% is comprised of heavy-duty vehicles (17 vehicles). Truro has no current plans to add or reduce the number of vehicles in their heavy-duty fleet. The targeted percentage of heavy-duty ZEV vehicles in the fleet is detailed in Truro's baseline municipal building emission portfolio presents strong emission reduction potential over the next 25 years. Table 2 summarizes the timeline of Truro's municipal emission reduction. The majority of Truro municipal building emissions are generated from electricity use. Without any ECMs, these emissions will decrease as the electrical grid transitions to cleaner generation sources. Truro's building portfolio is also poised to reduce both emissions and overall energy consumption by implementing ECMs that will increase the energy efficiency of municipal buildings. This roadmap proposes ECMs that will

reduce Truro's EUI by 97% by 2050. Further major equipment replacements will reduce Truro's municipal building emissions by 97% by 2050.

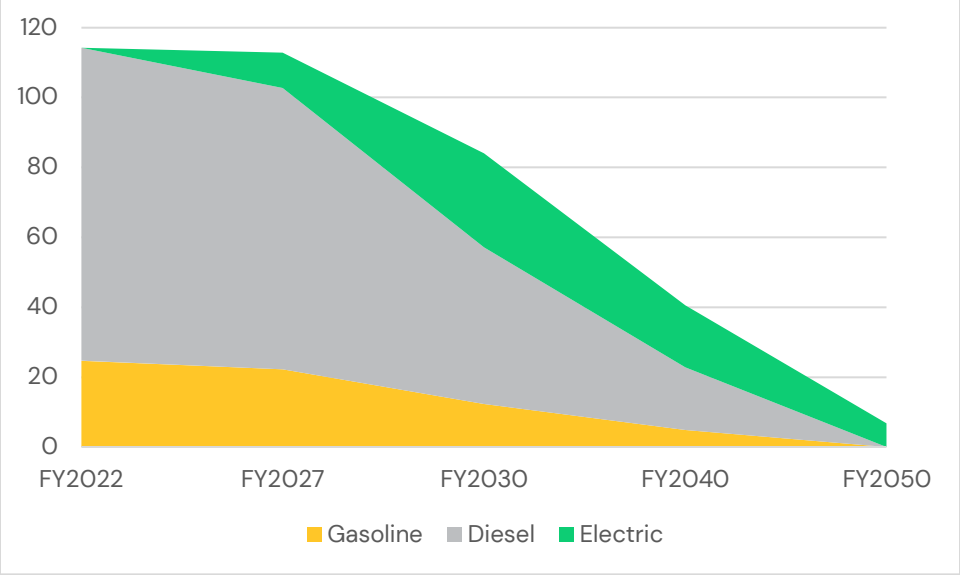
Table 2. Summary of Municipal Emissions Reductions.

Estimated Municipal Fleet Emissions

By transitioning the municipal fleet based on the Truro's baseline municipal building emission portfolio presents strong emission reduction potential over the next 25 years. Table 2 summarizes the timeline of Truro's municipal emission reduction. The majority of Truro municipal building emissions are generated from electricity use. Without any ECMs, these emissions will decrease as the electrical grid transitions to cleaner generation sources. Truro's building portfolio is also poised to reduce both emissions and overall energy consumption by implementing ECMs that will increase the energy efficiency of municipal buildings. This roadmap proposes ECMs that will reduce Truro's EUI by 97% by 2050. Further major equipment replacements will reduce Truro's municipal building emissions by 97% by 2050.

Table 2. Summary of Municipal Emissions Reductions, estimated municipal fleet emissions are shown in Figure 20.

Figure 20. Emissions over time from Truro's municipal fleet by fuel type (MTCO2e)



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 Truro's community.

Program Management Plan for Implementation, Monitoring and Oversight

Lead Implementers

With the support of stakeholders, funding, and this guiding Roadmap, Truro 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 Truro government, businesses, and residents. The Roadmap provides a strategic, portfolio-level approach to prioritize and implement decarbonization measures at Truro's buildings. The DPW is the lead department for facility operations and maintenance, budget approvals and energy management. It may engage with designers, consultants and other third-party agents to align the roadmap capital improvement plan with the Commonwealth's decarbonization goals in the most cost-effective way

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, Truro will also update this 2024 Roadmap to reflect accomplishments and new opportunities.

Roadmap Maintenance

The DPW will be primarily responsible for maintaining this Roadmap and monitoring progress toward the 2050 goal. The Department may engage consultants and committees to assist in this.

Technical Appendix

Truro 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.

	2022	2025	2030	2040	2050
Electricity (kWh)	0.000235	0.00022	0.000118	0.0000485	0.000015
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, 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.[5] These factors provided the percentage of total consumption for each end-use by energy source.

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

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.

Note: As the commercial EIA factors did not include an end-use energy value for pump equipment used in water and wastewater treatment plants, the lighting ECM for these facilities overcounts for the impact of lighting retrofits (i.e., assumes that all electricity end-use consumption is from lighting and not for other equipment). For these facilities, the eligibility assumptions for the lighting ECMs were reduced by 90% to account for the overrepresentation of lighting end-use in the savings calculations.

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	Weatheri-zation	Envelope/ Insulation	HVAC Controls	HVAC Electrifi-cation	Water Heating Electrification
Town Hall	630.67	630,670	62.61	10,074	0%	0%	100%	0%	100%	100%
DPW Carpenter Shop	49.90	49,900	61.15	816	100%	100%	100%	100%	100%	100%
DPW Sweeper	71.59	71,590	88.38	810	100%	100%	100%	100%	100%	100%
Beach Office	51.63	51,630	51.64	1,000	25%	25%	25%	0%	0%	0%
Community Center	465.66	465,660	50.37	9,245	100%	100%	100%	100%	100%	100%
Snow's Field	25.87	25,870	46.20	560	100%	20%	0%	100%	100%	0%
Library	724.60	724,600	64.27	11,275	20%	0%	75%	100%	100%	100%
Harbormaster	31.74	31,740	125.93	252	100%	100%	100%	100%	100%	100%
Public Safety PFR	916.65	916,650	88.91	10,310	0%	50%	0%	0%	100%	50%
DPW Office	141.56	141,560	287.72	492	100%	100%	0%	0%	100%	100%
Swap Shop	13.68	13,680	14.25	960	100%	100%	100%	0%	100%	100%
Transfer Station	122.51	122,510	274.69	560	100%	0%	20%	0%	0%	0%
School	2186.38	2,186,380	61.44	35,000	100%	100%	0%	0%	100%	50%
DPW Garage	256.18	256,180	100.07	2,560	100%	100%	100%	100%	100%	100%

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[6]) 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[7]) 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[8]	$/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 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[9]	$/sqft

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

[7] 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

[8] ICF assumption.

[9] 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.

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[10]. 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[11]	$/sqft
HVAC Electrification	$17.87[12]	$/sqft

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

Water Heating Electrification

To estimate energy savings from electrifying existing 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 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[13]	$/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.[14] 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

[10] ACEEE Electrifying Space Heating in Existing Commercial Buildings
[11] Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS) Data
[12] Energy Home, DEP, Montgomery County, MD (montgomerycountymd.gov)
[13] Energy Home, DEP, Montgomery County, MD (montgomerycountymd.gov)
[14] PVWatts Calculator (nrel.gov)

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[15]	$/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), 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 2050. 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.

[15] https://www.masscec.com/resources/commercial-solar-information-hub