

Town of Natick

Implementing a Zero Carbon Library



Morse Institute Library, Climate Preparedness Week, September 2021

2021 Green Communities

Block 2: Implementation Grant

Natick's Commitment to Green Communities and Net Zero Emissions

The Town of Natick has a history of setting and achieving big climate goals - *and pursuing them in a strategic and cost effective manner.*

In 2010, Natick became a founding member of the Green Communities program and committed to reducing municipal energy use by 20%. In 2012, it achieved this goal, primarily through the strategic replacement of aging HVAC equipment with high efficiency alternatives and fuel conversion.

In 2018, Natick Town Meeting adopted a community-wide emissions reduction goal, and in early 2021, every major local board and committee endorsed Natick's first Net Zero Action Plan. One of the action items identified in the plan is "to lead by example by constructing, retrofitting, and maintaining Town-owned buildings to reduce energy use and maximize clean energy technology to the extent feasible." With its eye on a net zero future, the Town is focused on capturing planned replacements of aging/failing heating and cooling systems as opportunities to integrate clean energy technology.

The Department of Energy Resources will play an important role in these projects and Natick was pleased to receive a custom engineering grant in Block 1. That funding was critical to bringing our proposed project from concept to final design, and today, the Town seeks DOER's partnership in taking the project to completion.

Enclosed is Natick's application for a Block 2 custom implementation grant. This grant will support the final stage of a year-long process the Town of Natick, DOER, UMass Clean Energy Corps and Eversource have undertaken to study, design and develop a bid package to 1) convert the Morse Institute Library's failing chiller to a heat pump system that leverages the building's ice storage tanks and 2) replace the Library's aging building management system with state-of-the-art energy efficiency controls.

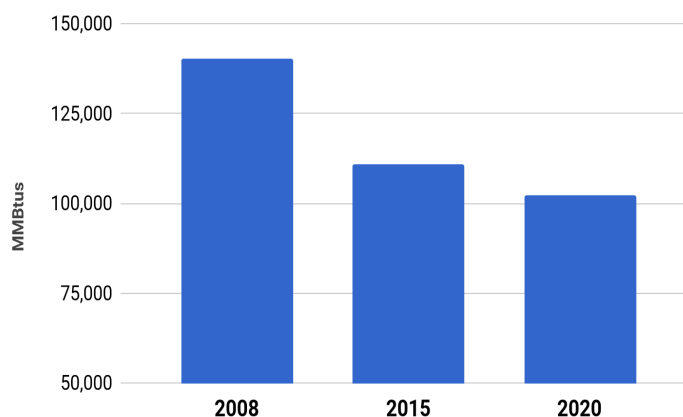
Total Municipal Energy Consumption

Natick met its Energy Reduction Plan target in 2012 and continues to pursue opportunities for energy conservation. In Fiscal 2021, the Town's total municipal energy use was 102,198 MMBtus (27% lower than its baseline when adjusted for changes in building stock).

Note, all FY21 figures are estimates and will be finalized as part of Natick's Annual Report.

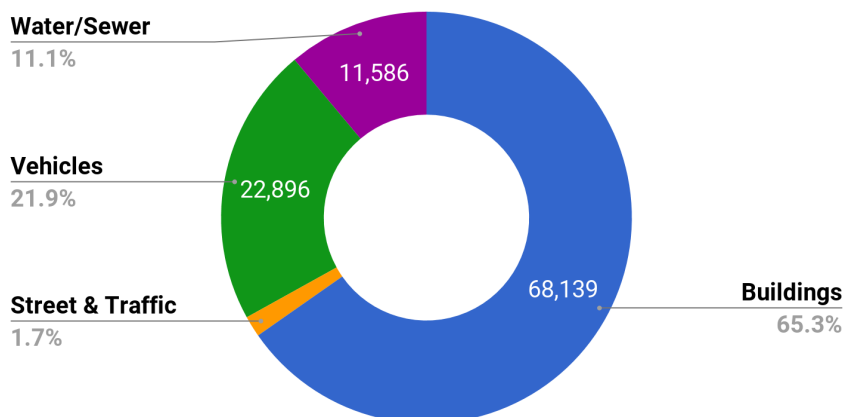
Buildings account for the majority of Natick's energy use. In FY21, which was heavily influenced by shutdowns due to Covid-19, buildings comprised 65% of the Town's energy use; in a more typical year, they account for closer to 70%.

Natick Energy Use
Baseline vs. FY 2020



Natick Energy Use in FY 2020

By municipal source, in MMBtus



Morse Institute Library: Energy Use and Building Profile

Natick's grant request is focused on decarbonizing the Morse Institute Library, the Town's oldest public building. The Morse Institute Library was built in 1873 and sustained a series of additions in 1927 and 1964. A large renovation of the building was completed in 1997 that preserved and paired the 1873 building with a large modern addition. Today the building is 60,860 square feet, houses more than 299,105 books and materials, and welcomes nearly 1,000 patrons each day.

Building	Electricity Use in FY21*	Natural Gas Use in FY21*
Morse Institute Library 14 East Central St, Natick, MA	433,120 kWh	19,486 therms

**Energy use in FY21 continued to be impacted by COVID-19*

Over the past five years, Natick has worked hard to understand the primary drivers of energy use at this building and has completed a variety of Green Communities grants to reduce energy consumption. Prior to Covid-19, the Town was able to reduce its energy use at this building from 2017 to 2019 by 17%, with the primary savings coming from electricity reductions.

The Town has struggled to achieve significant natural gas reductions due in part to an aging building controls system. However, over the years, some small reductions have been achieved.

Project Scope

Purpose

The purpose of this project is to simultaneously reduce energy use and carbon emissions while addressing significant and necessary repairs at the Morse Institute Library. This will be achieved by pairing deferred maintenance repairs and upgrades with forward-thinking investments in building infrastructure, specifically, the replacement of a failing chiller and aging building energy management

system (BMS) with a heat pump and state-of-the-art building controls. The modern electrified HVAC and controls system resulting from this project will use less energy, lead to significantly reduced greenhouse emissions, and constitute a necessary step to achieve our net zero carbon goals by facilitating increased use of renewable energy.

Background

The Morse Institute Library's major HVAC components were installed with the 1997 renovation and are now at or past the end of their useful life. The existing air-cooled chiller is failing, and the BMS is not functioning as intended and is in need of replacement. Both of these projects are on Natick's capital plan, and instead of replacing like-for-like, the Town is interested in making strategic investments in clean energy technology that put the Morse Institute Library on a path to becoming a zero carbon building.

In investigating this opportunity, Natick worked with the UMass Clean Energy Corps to study the chiller and existing controls system, and identify pathways to decarbonization. UMass's recommendations were explored and analyzed, with the support of Eversource, through an energy study, and a basis of design for a new air-to-water heat pump solution was developed. In summer 2021, Green Communities helped Natick fund the necessary design of a full bid package of drawings and specifications for the heat pump, while the Town also funded a bid package for the new building controls.

Today, the Town seeks funding from Green Communities to install the new air-to-water heat pump to replace the existing air-cooled chiller, while also replacing the existing end of life BMS and implementing a number of energy conservation and retro-commissioning measures in the process to reduce demand on the new heat pump system and facilitate its optimal operation.

Air-to-Water Heat Pump

The proposed heat pump can produce the same amount of chilled water cooling in the summer and a corresponding amount of hot water heating in the winter to displace much of the need for running the existing gas-fired hot water boilers. The existing thermal energy storage (TES) system will allow the heat pump to store cooling energy in the ice tanks at night and run the heat pump in heating mode during the day. Then, by melting the ice from the tanks to provide cooling to the building, the HVAC system will be effectively providing the same simultaneous heating and cooling functionality as a typical chiller-boiler setup. This setup helps the Town with their objectives of replacing the existing failing air-cooled chiller with a new, reliable technology that can work with the rest of the building infrastructure and transition to an electrified heating system to achieve a fossil fuel phase out goal.

BMS Upgrades

As discussed above, the existing building management system is past the end of its useful life, its hardware is obsolete (replacement parts are only available on eBay), and its performance has been significantly below what it was intended to provide. Replacing the existing air-cooled chiller with a new heat pump without upgrading the controls system would lead to an unsuccessful heat pump project. By installing a modern controls system with enhanced communication functionality and the ability to implement advanced sequences of operation, the heat pump will be enabled to achieve its full potential for energy efficiency and temperature control performance. Additionally, as part of the controls system upgrade, we intend to implement a number of energy conservation measures and to repair a number of retrocommissioning-style issues, such as broken dampers, failed sensors, and equipment out of balance. These measures will reduce the building's demands for heating and cooling, reducing the load on the new heat pump, saving on the capital construction cost for the project and ensuring that Town staff and Library patrons recognize the full benefits of the new system.

This project will comprehensively upgrade the controls on all HVAC systems controlled by the existing Trane Tracer Summit and ineffective Niagara overlay system and migrate them to a new BAS platform.

This upgraded BMS will fully integrate the new air-to-water heat pump controls and allow for optimization of the HVAC systems. Energy saving measures in the scope include:

- Optimal start/stop controls,
- Static pressure reset,
- Discharge air temperature reset,
- Improved unoccupied setbacks.
- Improved economizer control,
- Repairing leaking control valves,
- Repairing leaking air dampers,
- Replacing failed VFDs,
- Converting fans from inlet-guide vane control to VFD control,
- Adding CO2 demand control ventilation, and
- Load shedding for demand response/management.

The new BMS will also have the ability to be viewed remotely via web-access to enable Natick facility personnel access at all times. (This is currently not possible.)

The bid packages of drawings and specifications for the air-to-water heat pump and new building controls are attached.

Benefits

Makes electrification possible, reduces future retrofit costs and aligns with the tenets of the 2030 CECP

Massachusetts's goal is to achieve net zero greenhouse gas emissions by 2050. The Interim Clean Energy and Climate Plan for 2030 correctly states that "any system or piece of infrastructure that has a useful life that extends to or beyond 2050 and is being installed or replaced in the next decade either needs to align with the Commonwealth's decarbonization pathways or will need to be replaced before the end of its useful life. This is particularly important for natural gas infrastructure, building envelopes, district systems, and building HVAC, which may or may not be replaced between now and 2050 depending on the system and use."

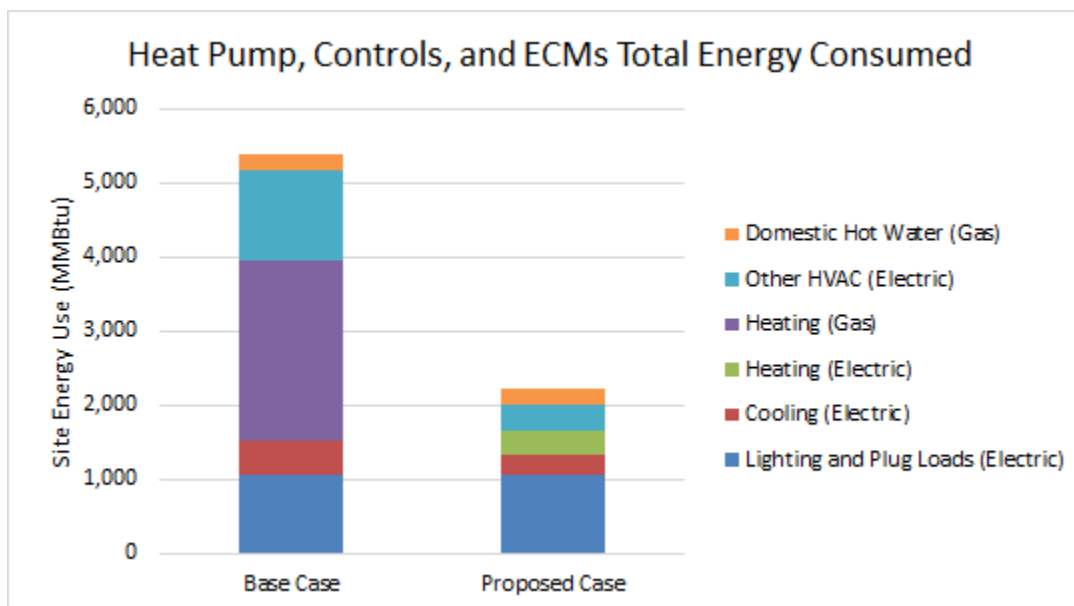
This is exactly the situation Natick is dealing with at the Morse Institute Library. A like-for-like replacement of the failing chiller would have a useful life that extends to or beyond 2050, therefore requiring a future retrofit to support the Commonwealth and Natick's net zero goals. Replacing the failing chiller with an air-to-water heat pump will allow Natick to both heat and cool the building at high efficiency and low cost, and will enable the eventual zero-carbon emissions operation of the library.

Upgrading the BMS controls is a necessary parallel step to allow for the expected energy performance of the heat pump system to be realized via more reliable communication and hardware, as well as the optimization of the remaining HVAC system through energy efficient sequence of operations that are not possible with the existing system. With the Morse Institute Library acting as a 'Cooling Center' for the Town during extreme temperatures and heat waves, a highly functional and reliable BMS is crucial to building operations and also in helping achieve its targeted energy goals in the future.

Significantly reduces fossil fuel use and greenhouse gas emissions

The air-to-water heat pump's ability to operate with outside air temperatures as low as 0°F and produce hot water up to 143°F greatly enhances the Town's objective of phasing out fossil fuels as much as possible at this stage. While the heat pump is not capable of heating and cooling at the same time, the availability of the existing thermal energy storage (TES) system allows for the heat pump to store cooling energy in the ice at night and run in heating mode during the day, effectively providing the same simultaneous heating and cooling functionality as the existing gas-boiler and electric chiller within a single piece of equipment. The TES system has sufficient capacity to cool the whole building for a full 24 hours on the hottest day of the year, so any cooling requirements can be met by melting ice while the heat pump runs in heating mode to provide reheat for any spaces that do not require full cooling. Similarly, when ambient conditions are conducive to airside economizer, the heat pump can be available to provide heating only because there is no further need for mechanical cooling. This setup is estimated to reduce gas-fired boiler use to just 5 to 10% of the heating season, effectively eliminating the need for the boilers to run on all but the coldest days of the year and thereby extending the boilers' remaining useful life and avoiding added capital costs to upgrade them.

Implementing the heat pump project alone, without the controls upgrade, would be expected to cut equivalent carbon emissions by nearly 5% by shifting heating energy from natural gas to electricity; however, the improved heat pump performance and energy conservation measures achieved concurrently with the controls upgrade project are also expected to reduce carbon emissions by over 35%, yielding a net project carbon reduction of over 40%.



Reduces demand on boilers and eliminates need for second boiler, thereby lowering future capital costs

Further, the two boilers, as currently used, are projected to require replacement in 5 to 7 years. Implementation of the air-to-water heat pump will allow for the boilers' usage to be reduced significantly enough that their life span can be extended due to reduced run time and do not need to be replaced at all in the foreseeable future. For reference, a single, standalone boiler is estimated to cost approximately \$150,000.

Eliminates R22 refrigerant, an extremely potent greenhouse gas

The existing chiller system uses R22 refrigerant, which has been phased out. By replacing the chiller, instead of investing in a compressor repair project, Natick will capture and responsibly destroy the remaining R22.

Leads by example and creates proof of concept for municipal electrification

Like the Commonwealth, Natick is asking residents to electrify their homes and convert to heat pumps in support of a net zero future. However, the municipality has no standout examples of applying this strategy to its own buildings. Adopting this technology in a building like the Morse Institute Library, a complex building with new and historical attributes that is heavily utilized by the public, will establish local best practices for Natick's Facilities Management team as they prioritize electrification in future capital projects - and will serve as an example for residents as they seek to make changes to their own homes.

Timeline

Given the failing chiller, Natick is eager to complete this work before the 2022 cooling season and expects to go out to bid for this project immediately upon the grant's approval. As the Engineer of Record for the drawings and specifications associated with the bid packages prepared to support this application, B2Q will remain involved with the project by providing construction administration and bid assistance services to see the project through to completion. Bidding and contract negotiation with the winning bidder are expected to take 4 - 6 weeks. Lead times on major equipment are expected to be long given current market conditions, possibly on the order of 12 - 16 weeks, so Natick will be eager to work with DOER to secure grant funding as soon as possible, if awarded, so that equipment can be ordered right away and ideally installed prior to summer 2022.

Procurement

The project is expected to be procured under M.G.L. Chapter 149A As a public construction bid of the engineered drawings and specifications produced through our Block 1 engineering grant from Green Communities.

Anticipated Impact

This project will put the Morse Institute Library on a path to become a zero carbon building and is anticipated to reduce annual emissions by approximately 180 metric tons of CO2 equivalents (by eliminating 24,000 therms of natural gas and reducing electricity use by 135,000 kWh*, per year). Per the U.S. EPA carbon equivalency calculator, the anticipated emissions reduction is equivalent to taking 23 passenger vehicles off the road. This will also result in annual energy savings to the Town of approximately over \$40,000.

*Natick has invested in prior energy efficiency projects at the Morse Institute Library. An analysis of 2017 vs. 2019 demonstrates a decrease in electricity consumption of 178,640 kWh. Additionally, as outlined above, the electrification of the heating system will allow for a greater deployment of renewable energy in the future, thereby enabling even greater energy cost and carbon reduction.

Alignment with Five-Year Energy Reduction Plan

2021 marks the eleventh anniversary of Natick's participation in the Green Communities program. Our initial five-year energy reduction plan is no longer in effect. In 2021, the Town adopted a new Net Zero Action Plan. This project directly supports Action #11, which states that, "The Town of Natick will lead by example by constructing, retrofitting, and maintaining Town-owned buildings to reduce energy use and maximize clean energy technology as much as feasible."

Permits Required

A general construction permit from the Town of Natick, as well as associated sub-trade permits, such as electric, plumbing, etc., will be required for installation. The drawings and specifications produced in the engineering phase were completed to a level of detail required to secure a permit. A brief

intermediate step will be required between awarding the bid and applying for the permit to update the drawings with any relevant changes from the bid process and to have the updated drawings stamped by a professional engineer.

Other Approvals

No additional approvals are required.

Education and Outreach

The Morse Institute Library has been a great partner for education and engagement on energy reduction and climate projects. In 2020, Library volunteers created and displayed a “climatestry” that depicted the warming temperatures Massachusetts has experienced over the past 100 years via a stitched blanket (see application cover photo), and the Town will seek to work with the organization’s Board of Trustees to explore creative, visual ways to highlight the Morse Institute Library’s planned transition to zero emissions.

As part of this grant, the Town will:

- Alert local media upon receipt of the grant
- Include information about the project in the Sustainability e-newsletter
- Post details about this and other DOER-funded projects on the Town’s website
- Present an update on this project, in the context of Natick’s larger municipal electrification goals, to the Board of Selectmen, Finance Committee and Morse Institute Library Board of Trustees
- Host a special building tour with residents to show how the Library’s new heat pump and controls operate, save energy and reduce emissions
- Partner with DOER on op-eds or media outreach to highlight this project as a case study for other communities

Description of Applicant and Project Team

The project team will include:

- *Jillian Wilson-Martin*, *Sustainability Director, Town of Natick*: Ms. Wilson-Martin will serve as the municipal project manager and will ensure this project is completed on time and within budget. She will host weekly calls with the project team and manage all administrative aspects of the project.
- *William Spratt*, *Facilities Management Director, Town of Natick*: Mr. Spratt will oversee the project from start to finish, from bidding to contractor selection to installation and commissioning. Ultimately, Mr. Spratt and his team will be responsible for operating the new systems and he has been deeply involved in the design process to-date.
- *Bryan Leblanc*, *Procurement Officer*: Mr. LeBlanc will support the bidding and contracting process for this project.
- *B2Q*: B2Q is the Engineer of Record who prepared the drawings and specifications for bid to support this grant application and they will remain involved through construction by providing construction administration services, as required by code. In this way, B2Q will continue to advise the town so that the construction proceeds in accordance with how it was designed and intended to operate.
- Natick may also elect to hire an independent third-party commissioning agent or may contract with B2Q to provide these services in addition to construction administration. The

Commissioning Agent will be responsible for testing the newly installed equipment to confirm that it was configured and programmed properly to achieve the design intent.

Additional Information

Weatherization and Efficiency Efforts to-date

With Green Communities help, Natick has invested significant time and dollars into understanding and executing on opportunities to maximize energy efficiency at the Morse Institute Library.

In 2014 and again in 2017, the Town worked with Peregrine Energy Group to complete circuit-level monitoring to identify energy intensive building equipment and match operations and energy use to building occupancy. Guided by these findings, the Town adjusted controls sequences and completed a variety of energy conservation measures, including, but not limited to: interior and exterior LED conversions, installation of occupancy sensors, addition of variable frequency drives, and the replacement of an aging, oversized Liebert system with a right-sized, ductless mini split in the archive room. As a result, the Town has been able to reduce the Morse Institute Library's energy usage by 17% between 2017 and 2019 (pre-Covid).

Weatherization has also been top of mind for Natick. The addition from 1997 (which represents the majority of the building's square footage) is reasonably well insulated and sealed per the codes at that time, but the envelope of the original, 1873 building may benefit from weatherization. However, opportunities may be limited due to its historic nature. In response, the Town has allocated funding to complete a building envelope study that will inform this work. In the interim, because the chiller is failing and building controls need to be replaced to maintain building operations, the Town hopes DOER will be flexible regarding the timing of the envelope study.

Efficiency Comparison of Existing Chiller and Proposed System

The existing aging chiller had a design nominal efficiency of 1.15 kW/ton, although, as described above, its current condition is poor and it is likely not operating as efficiently as it was designed to. The supporting plant equipment, such as the controls and pumps, are not operating as efficiently as they could either, as detailed in our energy study report. The new heat pump have a nominal efficiencies 1.17 kW/ton in design conditions, but as low as 0.75 kW/ton at part load (where the system is expected to operate most of the time).. The proposed heat pump will also almost entirely eliminate the need for natural gas, with only around 100 therms for the boilers estimated in the maximum decarbonization system sequence of operation.

Feasibility Study

In parallel with the design efforts for the new heat pump and controls systems, B2Q, with the support of Eversource, prepared an energy study quantifying the expected benefits of the new equipment and operating strategies. A copy of this study is attached.

Thank You

The Natick team is thrilled to submit this project for your consideration.

We realize this application represents new and uncharted territory for the Green Communities program, and for Natick too! Electrifying our existing building stock won't be easy, and DOER's support is absolutely critical in taking projects like the Morse Institute Library from design to reality. Thank you for taking this journey with us.

*Natick: Pursuing a Zero Carbon Library
Implementation Grant Application, Project Narrative*

Please know that our team is open to your feedback and questions. We hope we can work together to make this a successful case study for Massachusetts.

Thank you for considering our application.