Energy Infrastructure Assessment Report
FINAL

For

Montague, Massachusetts

May 8, 2018

Prepared by

UMass Clean Energy Extension

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Executive Summary

The Town of Montague has engaged with the UMass Clean Energy Extension (CEE) to:

1) Review municipal energy consumption information in the MassEnergyInsight (MEI) platform;
2) Examine the condition of energy infrastructure within Montague's 13 municipally owned buildings, infrastructure, and associated energy systems;
3) Provide recommendations and prioritize energy conservation measures (ECMs) for Montague's municipal buildings and infrastructure;
4) Identify funding mechanisms for further exploration by the town;
5) Help Montague better focus future energy audits; and,
6) Provide additional detailed building analyses to support further engineering studies and/or the solicitation of contractor quotes.

Using municipal building information and historical energy data, our findings and recommendations for Montague are summarized below. These specific buildings have been identified as *high priorities* for the town based on a combination of overall energy consumption and opportunities as further discussed in the report.

- **Total Municipal Energy Consumption** - The total energy usage in Montague in FY 2016 was 30,636 MMBtu [million Btus]. Of this total, 41% was used for heating (natural gas and heating oil), 38% used for electricity, and 21% used for transportation (gasoline and diesel). The ECMs funded through the 2016 Green Communities Competitive Grant Program are still being implemented. In addition to previous projects, their completion will allow Montague to reach its 20-percent reduction from the established baseline year.
- **Sheffield Elementary School** – The Sheffield Elementary School has both the highest overall energy consumption and *energy use intensity* (i.e., energy consumption per square foot of conditioned space). The school has the highest heating fuel consumption and the second highest electricity consumption. Heating fuel accounts for 83% of the building's energy consumption. Thermal improvements to this building will have a significant impact on the town.

  As such, Montague should consider allocating funds to projects such as the replacement of windows, air sealing/weatherization in the mechanical room, exhaust vents, exterior doors, stratifying fan in the auditorium, and bulk water management and structural repairs.
- **Water Pollution Control Facility** – Montague's Water Pollution Control Facility (WPCF) is a relatively significant energy user and, as such, warrants a closer look for energy reduction opportunities. Because wastewater treatment plants (WWTPs) contain specialized industrial-scale equipment, numerous WWTP-specific assistance programs can be taken advantage of. It is recommended that Montague contact the resources detailed later in the report appendices to identify funding and project support opportunities.
- **Hillcrest Elementary School** – Hillcrest Elementary has the second highest heating fuel consumption, as well and a relatively high energy intensity. Montague should consider examining opportunities to update building HVAC controls, insulate any ductwork, seal any access hatches, and air seal and insulate the existing passive ventilation system.
- **Police Department** – The Police Department consumes a large amount of both electrical and thermal energy, and the building has the second highest energy intensity of all buildings examined. Montague

should further assess building set points, scheduling and operation of the HVAC control system, and consider the installation of a roof-mounted PV system.

- **Town Hall** – The Town Hall is a large energy consumer and has a relatively average energy intensity. Overall, the Town Hall has the third highest electric and heating fuel consumption. Montague should consider further air sealing, and add additional insulation within the attic to improve the envelope once the roof has been replaced.
- **Carnegie Library** – The Carnegie Library has a relatively low energy consumption level and a high energy intensity. Due to its low energy usage, any improvements to this building will have a lower impact to overall municipal consumption than the other high priority buildings. However, due to the high energy intensity and severity of identified issues, Montague should consider funding an air quality assessment, review ventilation infrastructure, reduce air 'stack-effect' within the south stairwell, implement weatherization, and clearly delineate the envelope in to the main entranceway.

The following are broad-based findings and recommendations that apply across many of Montague's facilities and vehicles.

- **Building Heating Performance** – Our analysis for the buildings that have complete data shows that the facilities mentioned above have heating systems that fire at relatively moderate outside temperatures, which is an indication of poor thermal performance. Therefore, we recommend that Montague conduct **thermal energy audits** which further investigate building operations, heating controls (e.g., thermostat setbacks), and potential envelope improvements.
- **Transportation** – Transportation fuels account for 21% of the town's total municipal energy use. Montague should make it a **priority** to investigate strategies including but not limited to: route optimization, introduction of efficient hybrid or electric vehicles, and/or considering transportation efficiency best-practices as described within the report.
- **Recommended Audits** – CEE recommends that Montague purse ASHRAE Level II-III Technical Assessment Energy Audits for the following buildings:

  Carnegie Library– Thermal and Air Quality Assessment
  Town Hall – Envelope and Thermal Energy Audit
  Sheffield Elementary and Administration Building – Envelope and Thermal Energy Audit

CEE is grateful to Montague's staff, committee members, and town officials for their support and contribution to the development of this report. As a next step, **Montague may wish to contact CEE to schedule an initial conference call to discuss the findings herein** (413-545-8510, energyextension@umass.edu). This discussion may include a review the municipal energy analysis, target strategies, and support a plan for reducing municipal energy consumption. After the review call, the municipality may wish to schedule energy audits for highest priority municipal facilities identified in this report. When soliciting potential auditors, ensure they are prepared to consider both thermal and electric opportunities.

1. Introduction

1.1 Purpose of this Report

The UMass Clean Energy Extension (CEE) has been engaged by the Commonwealth's Department of Energy Resources (DOER) to support the state's municipalities in providing technical assistance to help them better understand their energy consumption and identify opportunities for adoption of clean energy technologies and/or practices. The purposes of this report, created on behalf of the Town of Montague (Montague) are to:

1) Present Montague's Municipal Energy Analysis Report (MEAR), created by CEE (D (**Sections 2 & 4**);
2) Provide recommendations and prioritize energy conservation measures (ECM) for Montague's municipal buildings and infrastructure (**Section 5**);
3) Describe and evaluate in detail the energy infrastructure and sources within Montague's 13 municipally owned buildings[1], and other infrastructure[2] (**Section 3**);
4) Identify funding mechanisms for further exploration by the town (**Section 7**);
5) Help Montague better focus future energy audits (**Section 7**); and
6) Provide additional detailed building analyses to support further engineering studies and/or the solicitation of contractor quotes (**Appendices**).

1.2 Green Communities Designation and Grant Program

Montague was one of the first municipalities within the Commonwealth to become a designated Green Community through DOER's Green Communities (GC) Designation and Grant Program. As of 2017, more than half of the cities and towns in Massachusetts are designated as Green Communities, and have received grants toward energy efficiency, energy conservation, and clean energy projects. This report provides Montague with a basis for pursuing additional Green Communities competitive grant funding going forward.

Since Montague's designation in May of 2010, the town has been awarded more than $256,299 for energy conservation projects through three competitive grants in 2012, 2014, and 2017 (**Table 1**).

1 Water Pollution Control Facility; Montague Libraries: Carnegie, Miller Falls, and Montague Center Library; Shea Theater; Colle Building; Public Safety Complex (Police Station); Gill-Montague Council of Aging (Senior Center); Town Hall; Sheffield & Hillcrest Schools (Gill-Montague Regional School District); Montague Airport Building; and, proposed Department of Public Works Building.

[2] Municipal Streetscape Lighting and Sewer Pumping Stations.

Table 1. Green Communities Grant Awards Secured by Montague

Award Date	Award Amount	Award Description
May - 2010	**$154,944**	To buy-down the cost of a performance contract, specifically energy conservation measures in the Town Hall, Public Safety Complex, and Carnegie Library building; lighting and lighting controls, building envelope and insulation, network controllers and programmable thermostats.
July – 2012	**$2,754**	To install a Return Activated Sludge variable frequency drive and motor.
July – 2014	**$ 84,935**	To fund the replacement of the rooftop unit for the Shea Theater.
July – 2017	**$168,610**	To fund energy conservation measures in municipal facilities including the Sheffield School, Shea Theater, and Carnegie Library. The energy conservation measures funded by the grant are: recommissioning pumps, lighting controls, replace rooftop units, HVAC ductwork replacement, and furnace and AC system upgrade with oil to propane fuel conversion

1.3 Project Background

CEE was initially contacted by a Montague Energy Committee Member in early spring of 2017 to help Montague further explore areas of opportunity for improved energy efficiency. Representatives from Montague and CEE met in June of 2017 to further discuss the best pathway for improving efficiency, and identifying and prioritizing recommendations for capital planning goals. Both parties agreed upon a developed scope-of-work, a summary of which is provided in **Section 1.1**. It is important to note that while the recommendations outlined in report could lead to quantifiable energy efficiency improvements and financial savings, this study does not replace further in-depth building analyses such as Level II and III ASHRAE audits required by DOER for Green Communities competitive grant eligibility. Furthermore, the analyses within this report were dependent upon both the quality and availability of the data provided to CEE from Montague, and that which CEE obtained from the town's vendors.

In addition to the creation of this report and identified deliverables, CEE facilitated the organization of Montague's MassEnergyInsights (MEI) account. Discussed in detail in **Section 2.1**, MEI is web-based database tool used to help designated Green Communities and/or aspirants track and analyze energy consumption. Because Montague became a designated a Green Community in 2010, it was exempt from using MEI at that time. To help Montague transition from the exempt reporting process to the current and state-preferred MEI-based approach, CEE completed the following tasks:

- Worked with Montague to identify status of municipal buildings pertaining to the facilities inclusion within, or exclusion from the original GC energy baseline;
- Created accounts for previously missing municipal facilities within MEI;
- Reviewed and analyzed completeness of data within each facility's accounts (e.g., heating fuels, electricity, and transportation fuels). For incomplete accounts, missing data was obtained from vendors and entered into MEI to the best of CEE's ability;
- Entered consumption data from all previous Green Community Annual Reports since Montague's designation; and
- Further organized and separated unassigned electrical, water, and sewer accounts.

1.4 UMass Clean Energy Corps

In 2016, CEE established the UMass Clean Energy Corps, designed to help propel UMass's educational mission and the clean energy goals of the Commonwealth by affording students the opportunity to help develop hands-on energy experience. Through the Clean Energy Corps, students have the chance to interface, contribute to, and collaborate with real-life business clients and projects. The program draws high caliber students from a myriad of graduate and undergraduate programs--predominately UMass-Amherst--and demonstrate the value of their integrated teaching, extension services, and research programs available to the public.

Under the direction of CEE's professional staff, two students and Clean Energy Corps members developed this report: Jeremy Price, a graduate student from UMass-Amherst (Dual Master's in Regional Planning and Sustainability Science) and Matt Raymond, an undergraduate from Hampshire College (Sustainable Building Science and Systems Analysis).

1.5 Municipal Background

The Town of Montague, located in scenic Franklin County (**Figure 2)**, is comprised of five villages: Turners Falls[3], Lake Pleasant, Millers Falls, Montague Center, and Montague City (**Figure 3**). Montague is situated along the Connecticut River in the upper Pioneer Valley, and at the crossroads of Interstate 91 and the Mohawk Trail (Route 2).[4] Montague is within a two-hour drive or less of Albany (NY), Boston (MA), Concord (NH), Hartford (CT), Montpelier (VT), Providence (RI), Keene (NH), and Springfield (MA). Electricity is provided by WMECo, DBA Eversource (**Figure 4**), and natural gas through Berkshire Gas Company (**Figure 5**).

Figure 1. View of the Connecticut River in Turners Falls bordering Greenfield

[3] Turners Falls is the largest of the five villages and contains over half of the town's population.

[4] The Mohawk Trail began as a Native American trade route, and officially opened as the first scenic road in New England in 1914. Today it stretches sixty-nine miles along Routes 2 and 2A, between Athol, MA and Williamstown, MA.

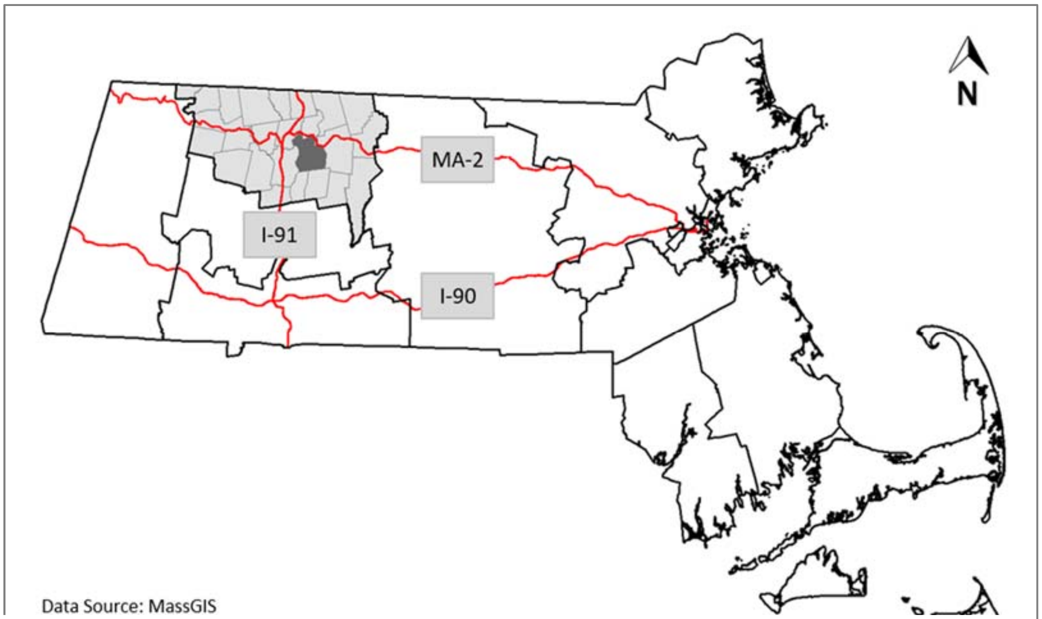


Figure 2. Regional context map

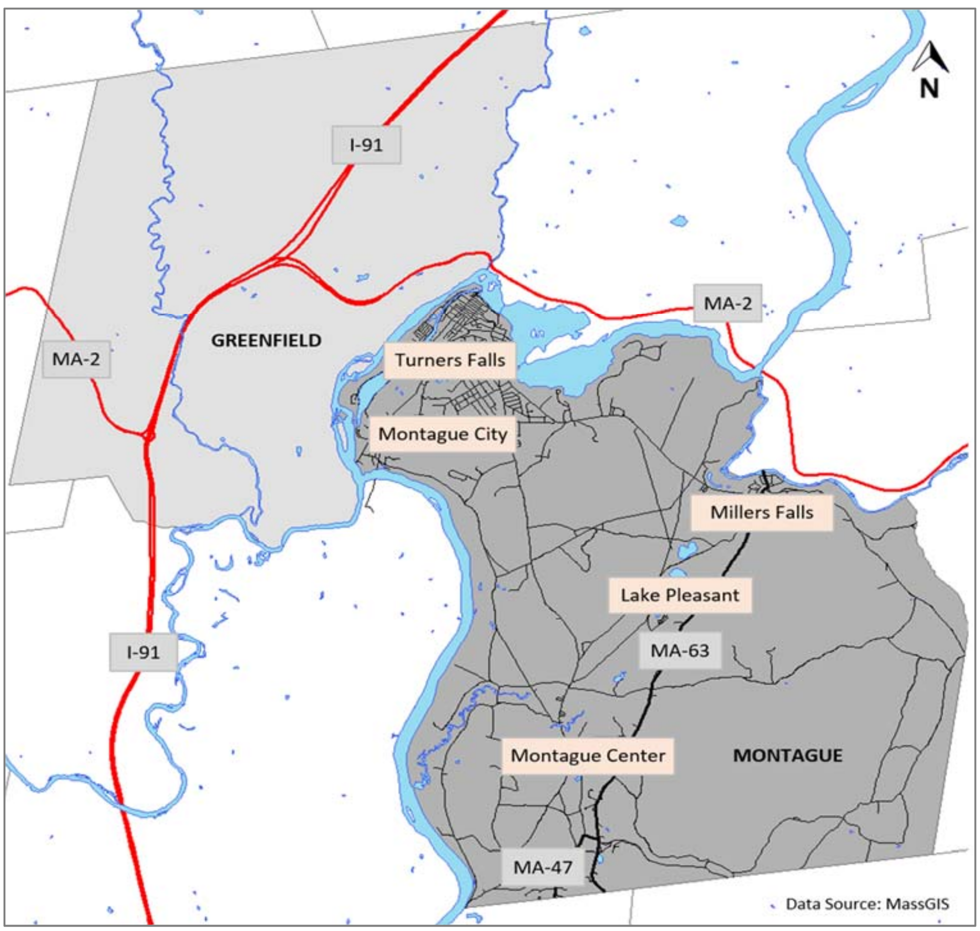


Figure 3. Local context map

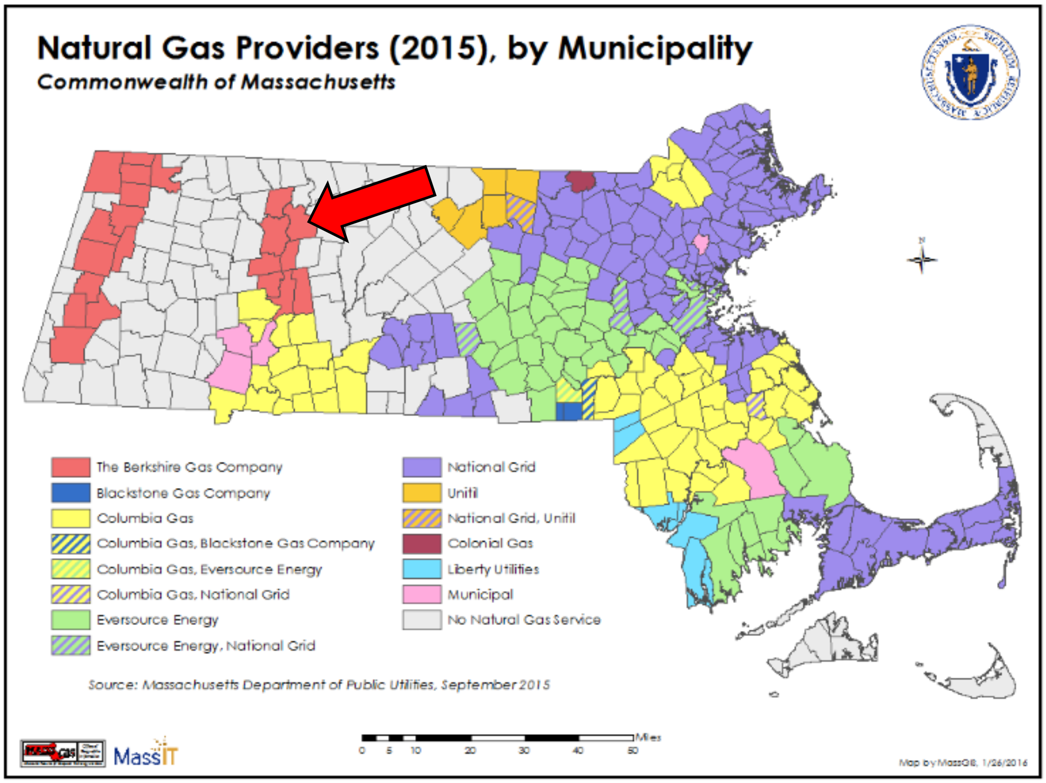


Figure 4. Regulated natural gas utility providers (MassGIS)

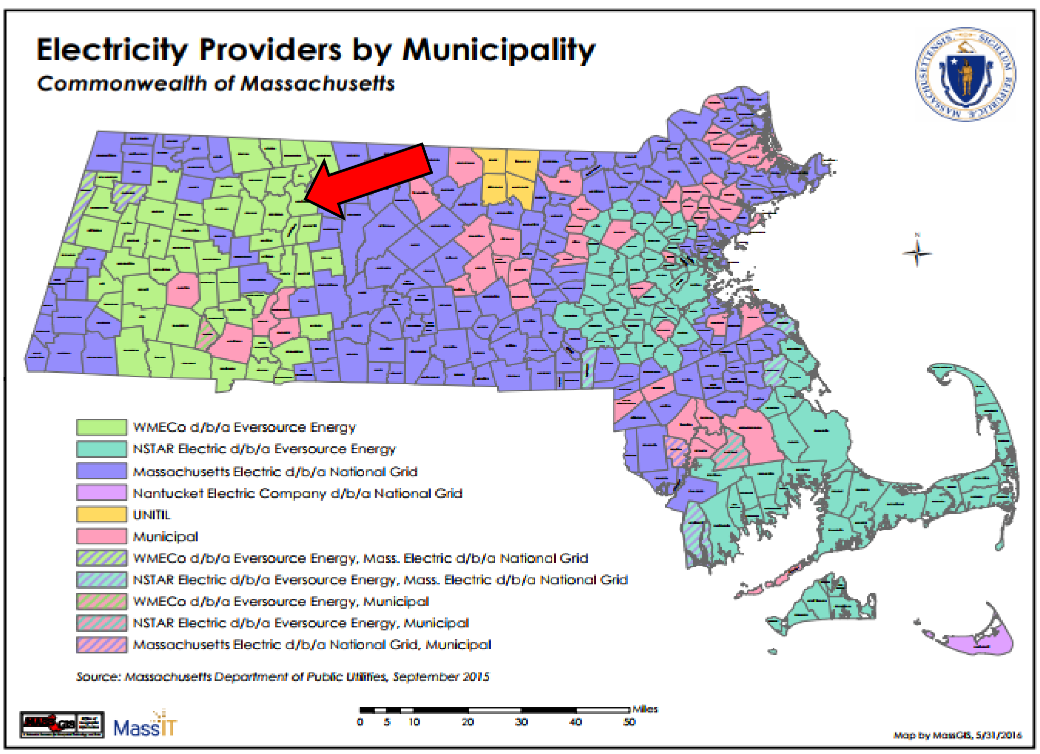


Figure 5. Regulated electricity providers (MassGIS)

Roughly 8,500 people live within the town's 31.5-square-mile footprint, which comprises rolling hills, fertile farmlands, historic mills and residential villages. There are many outstanding examples of late 19th- century architecture in the Turners Falls Historic District, listed on the National Historic Register of Places. Although this architecture greatly contributes to the town's charm and rich culture, the preservation and usage of these buildings also poses energy efficiency challenges.

Montague has consistently demonstrated its commitment to reducing municipal operating expenses and environmental degradation through energy efficiency improvements. In October of 2008, the Montague Board of Selectmen established the Montague Energy Committee (MEC) under Massachusetts General Laws Chapter 40, Section 81. This piece of legislation empowered the Committee with a broad mandate to support the town's efforts to reduce its carbon footprint through improved efficiency, including the residential and business sectors.

With the support of municipal officials, MEC has been instrumental in helping the town further its energy efficiency goals. These efforts include, but are not limited to:

- Connecting the Town of Montague with the UMass Clean Energy Extension for the completion of this report;
- Facilitating a series of home-weatherization workshops teaching residents how to reduce energy consumption through low-cost practices;
- Helping to raise $4,300 for clean energy projects through a clean energy matching grant program; and,
- Promoting the 2009 NESEA Green Building Open House, featuring nine municipal building. More than 100 people attended the tours.

As indicated by the Town Administrator, Montague has recently signed a lease agreement for the Kearsarge Energy's 5.99 Megawatt (MW) solar field at Sandy Lane; the Massachusetts Department of Environmental Protection (MassDEP) has issued a permit for the project. Montague's Director of Planning and Conservation, Walter Ramsey, has been instrumental in the facilitation of this project and Montague's commitment to energy efficiency, acquisition of grants, and grant management.

Through a proposed power purchase agreement (PPA), Montague would commit to buy 60 percent (total use about 2.05 MW) of electricity for Town facilities from Kearsarge at 85 percent of Eversource's going electricity rate for a 25-year agreement. Greg Garrison, an active member of Montague's Finance and Capital Improvement Committee has assisted Montague's navigation of that process. As of 2017, this is the largest project of its kind in Franklin County, including more than 18,000 solar panels. For aesthetic and safety purposes, a strip of wooded area between the road and solar field will be preserved to provide a visual buffer.

The Keith Block Apartments (**Figures 6** & **7**) located in Turners Falls are another example of Montague's progressive practice. Although the Keith Block Apartments are not owned or operated by the Town of Montague, but by the Montague Housing Authority, the modern wood heat conversion project is an important example for the region.

Funded by a grant from the School and Public Housing Integrating Renewables and Efficiency (SAPHIRE) program administered by DOER, and in coordination with the Massachusetts Department of Housing and Community Development (DHCD), The $288,000 project, had an estimated payback period of 7.4 years included design, construction and monitoring costs. This wood pellet heating conversion project serves 31 low-income family apartments and displaces roughly 11,515 gallons of heating oil annually.

SAPHIRE was designed to promote renewable thermal[5] heating and cooling upgrades in public schools and state public housing across the Commonwealth. Innovative projects within this program sought to combine renewable energy thermal heating upgrades with energy efficiency improvements to achieve greater reductions in consumption.

Figure 6. View of Keith Apartments from 3rd Street

Figure 7. View of Keith Apartments from Canal Street

[5] Renewable thermal heating and cooling (RHC) is the generation of energy from renewable technologies and resources to serve end-use application such as heating water, space heating and cooling, and process heating. Solar thermal, modern wood heating, air/ground source heat pumps, and district heating and cooling are all examples of RHC that generate thermal energy, provide savings, and seek to reduce associated environmental impacts.

2. Energy Accounts and Analysis

2.1 MassEnergyInsight & Accounts Overview

Data used in this analysis was provided directly to CEE by Montague officials, collected from vendors, or sourced from Montague's MassEnergyInsight (MEI) account. MEI is a web-based tool provided by DOER at no cost to all Municipalities in the Commonwealth. MEI enables cities and towns to develop an energy-use baseline, track and analyze energy use and costs, prioritize energy projects, and communicate about energy use and greenhouse-gas emissions. CEE has ensured that the town's MEI platform is accurate and current to the best of its abilities. Data from electric accounts are automatically uploaded to the town's MEI account. Delivered fuels (e.g., propane & gasoline) data is gathered from town municipal records or vendors, and entered manually into MEI. The data included in this report has been organized in alignment with the Massachusetts fiscal year (July 1st to June 30th).

2.2 Energy Consumption

The following graphs illustrate Montague's total energy consumption in FY 2016 and provide comparisons of the town's facilities and their individual utility accounts. Energy consumption by fuel type is shown in **Figure 8**. Heating oil accounts for 30% of the town's total energy consumption, suggesting that heated buildings may be an important focus area for energy efficiency efforts. Transportation fuels account for 21% of Montague's total energy consumption.

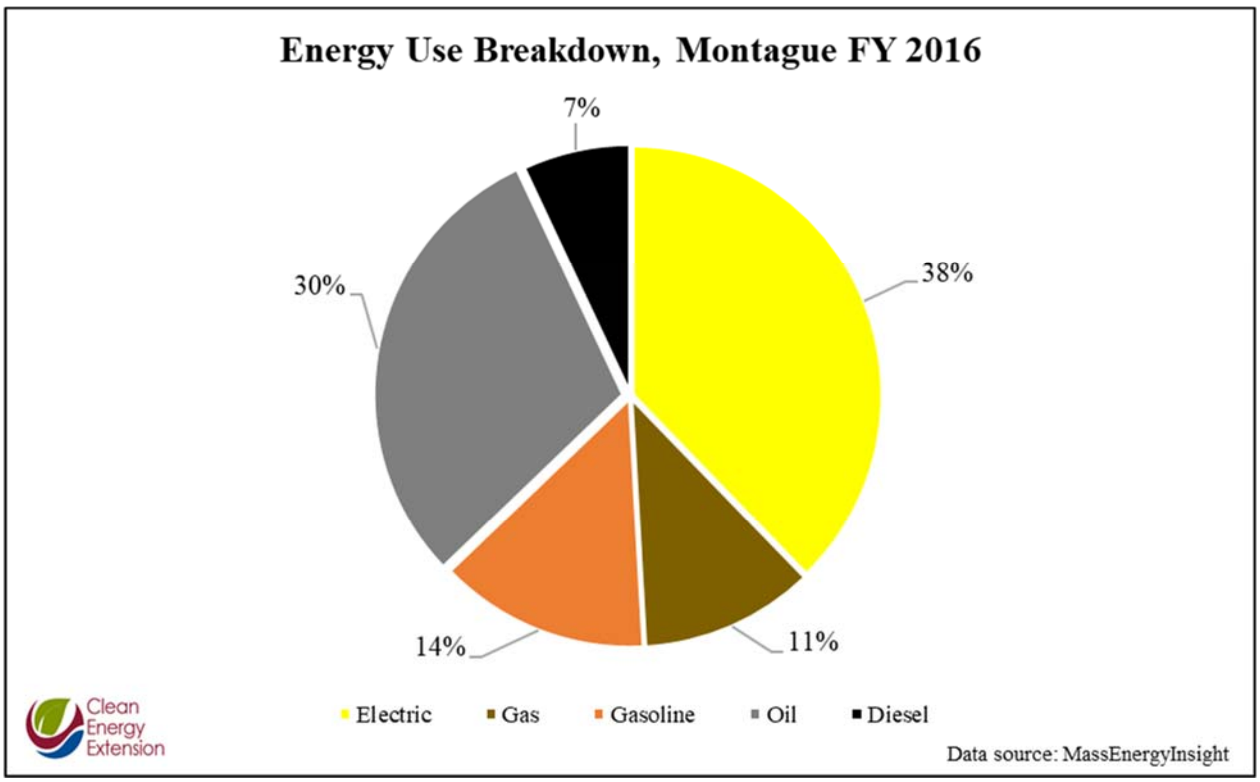


Figure 8. Total consumption of each energy type and its percentage of the town's total energy consumption. *Diesel from FY 2017

Montague's top 10 energy accounts (across all fuel types) with the highest energy consumption are shown in ranked order in **Figure 9** below. These accounts comprise 78% of Montague's total annual energy consumption, thus Montague should consider prioritizing these top accounts for further energy studies and subsequent energy efficiency projects.

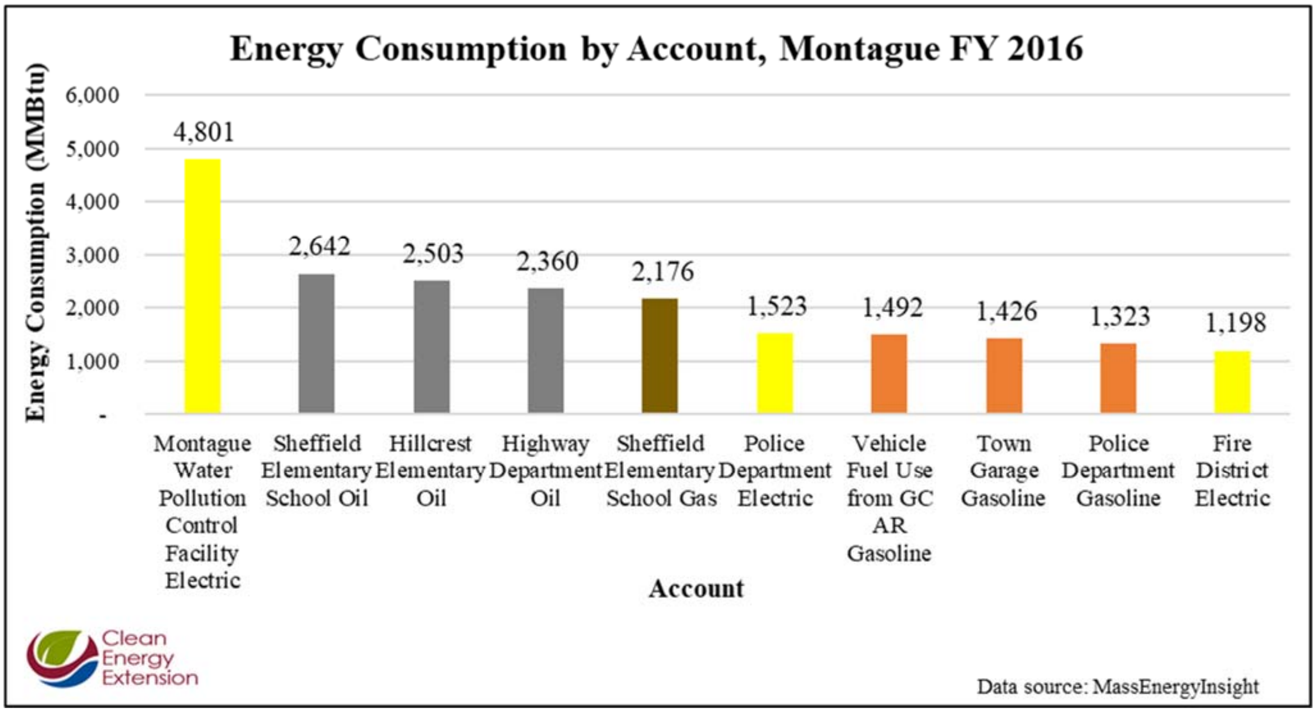


Figure 9. Top ten energy accounts

The wastewater treatment plant (WWTP) accounts for a significant portion of Montague's energy consumption. However, WWTPs are unique, energy-intensive facilities that are not comparable to other municipal buildings. Therefore, Montague's WPCF will not be discussed in detail. **Appendix A** provides information on resources supporting municipal WWTPs. Additional figures displaying the municipality's energy consumption are included in **Section 3.4** below.

2.3 Analysis Tools

Building performance as it relates to energy-related operations can be better understood through the application of a number of analytical tools developed by CEE for this report. The tools applied in this analysis include:

- **Weather Normalized Energy Consumption** – To account for annual variations in weather conditions, CEE has calculated the typical heating energy consumption, given the weather conditions for the selected year compared to the average weather conditions (from 1991 and 2005). This provides the town and auditors with an understanding of a facility's typical annual energy consumption.
- **Weather Normalized Energy Usage Intensity** – Energy use intensity (EUI) expresses a building's energy use as a function of its size, in terms of energy per square-foot-per year. It is calculated by dividing the total energy consumed by the building in one year (measured in kBtu) by the floor area of the building. Generally, a low EUI signifies good energy performance. EUI is a valuable metric to evaluate and compare energy performance regardless of building size. However, some building types are inherently more energy intensive than others. Buildings that have longer operating hours or require specific energy-intensive

equipment will typically have a higher EUI than other buildings. The heating-fuel portion of each building's EUI has been adjusted to account for varied yearly weather conditions, according to the protocol described previously. Considering energy consumption in conjunction with weather-normalized EUI can help identify buildings that could have a significant impact on the town's total energy consumption, depending on the available energy efficiency measures yet to be implemented.

- **Heating Performance Analysis & Balance Point** – The pattern of fuel consumption was compared with weather data (outdoor temperature) to identify the balance point for each selected building. The balance point is the outdoor temperature at which internal systems turn on to heat the building. A building with a balance point that is higher than 60°F is a good candidate for lifestyle (e.g., keeping overhead garage doors closed) or structural changes (e.g., adding Insulation) that would decrease the building's heat loss through the envelope.

3. Building & Infrastructure Inventory & Recommendations

Prior to reviewing the building energy analysis and recommendations, it is important to understand the current building stock, previously conducted studies, as well as understanding how improvements to a single building may affect the town's total energy consumption. A complete list of Montague's municipal buildings and relevant energy systems are in included on the following page in **Table 2**. Each facility's total energy consumption and contribution to municipal demand is shown in **Table 3**. This inventory and the analyses that follow are the basis for recommendations found in **Section 5.**

In addition to conducting walk-throughs of each municipal building, CEE reviewed several studies and/or audits made available by the Town of Montague in preparation for this report:

1) HVAC Upgrade & Energy Study (Shea Theater) – Bart Bales Energy Associates (2014)
2) Investment Grade Audit Report (Town Hall & DPW) – Siemens Industry (2010)
3) ASHRAE Level II Energy Audit (Sheffield Elementary School) – Sebesta, Inc. (2016)
4) Furnace, AC Units, & Control Replacement Proposal (Carnegie Library) – B2Q Associates, Inc. (2017)
5) Proposal for Rooftop Ductwork Replacement (Shea Theater)- B2Q Associates, Inc. (2017)

Table 2. Building & System Inventory

Building	Building Ownership Status	Year Built[1]	Distribution System[2]	Fuel Source	Gross Area (ft2) [1]	Municipally Identified Needs[3] (Y/N)
Airport Building	**Town Owned**	**1996**	**Forced Hot Air**	**Natural Gas**	**760**	**N**
Carnegie Library	**Town Owned**	**1912**	**Forced Hot Air**	**Oil**	**7,056**	**Y**
Millers Falls Library	**Town Owned**	**1900**	**Hydronic**	**Oil**	**1,320**	**Y**
Montague Center Library	**Town Owned**	**1800**	**Forced Hot Air**	**Oil**	**2,700**	**Y**
Hillcrest Street School	**Town Owned** (Utilities – GMRSD)	**1958**	**Steam**	**Oil**	**15,332**	**Y**
Sheffield Elementary School	**Town Owned** (Utilities – GMRSD)	**1904**	**Hydronic & Steam**	**Oil & Natural Gas**	**35,000**[4]	**Y**
Montague Public Safety Complex (Police Station)	**Town Owned**	**2008**	**Ground-source heat pump**	**Electricity**	**10,685**	**N**
Montague Senior Center	**Town Owned**	**1890**	**Hydronic**	**Natural Gas**	**1,658**	**Y**
Montague Town Hall	**Town Owned**	**1880**	**Hydronic**	**Natural Gas**	**13,000**	**Y**
Shea Theater	**Town Owned** (Utilities – Tennant)	**1928**	**Forced Hot Air**	**Natural Gas**	**11,400**	**Y**
Colle Building	**Town Owned** (Utilities – Tennant)	**1900**	**Forced Hot Air** (Separate Units)	**Natural Gas**	**14,440**	**N**
Water Pollution Control Facility	**Town Owned**	**1964**	**Hydronic**	**Oil**	**16,000**	**Y**

Notes: 1 - Obtained from MassGIS Level 3 Assessors' Parcel Data; 2 - Heat and/or cooling (only through Hydronic & Forced Air) can be distributed through a building in a variety of ways**: A. Hydronic (or hot water**): System uses hot water to heat the building through a closed-loop system. **B. Steam:** Vaporized water is passively circulated through the building, condenses in radiators and gravity fed back to closed-loop system. **C. Forced Hot Air:** Air heated by a furnace is distributed around a building through ductwork; 3 - Indicated in the municipally provided building and facility needs spreadsheet; 4 - Gross area Includes Sheffield Administration building.

Table 3. Municipal building energy consumption inventory (FY 16)

Building Name	Electric (MMBtu)	Oil (MMBtu)	Gas (MMBtu)	Total (MMBtu)	% of Total Municipal Energy Consumption
Sheffield Elementary School	954	2,642	2,176	5,771	28.7%
Montague Water Pollution Control Facility	4,801	695	-	5,496	27.3%
Hillcrest Elementary School	298	2,503	-	2,801	13.9%
Police Department	1,523	-	-	1,523	7.6%
Town Garage	-	-	-	1,426	7.1%
Town Hall	379	-	859	1,237	6.1%
Shea Theater	130	-	319	449	2.2%
Carnegie Library	90	201	-	291	1.4%
Montague Center Library	52	167	-	220	1.1%
Water and Sewer	207	-	-	207	1.0%
Colle Opera House	198	-	-	198	1.0%
Millers Falls Library	18	160	-	178	0.9%
Senior Center	42	-	119	161	0.8%
Airport	29	-	38	67	0.3%
Recycling Center	66	-	-	66	0.3%
Parks and Rec Fieldhouse	25	-	-	25	0.1%

*Blank cells indicate no data, or inadequate data.

3.1 Airport Building

This section (1) provides a general background of the Airport Building; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 4. Airport Building characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1996**	**768**	**Forced Hot Air**	**Natural Gas**

Existing Conditions

The Turners Falls Municipal Airport (FAA LID: 0B5) is an integral component of the transportation infrastructure within the Northern Tier of Massachusetts. The administration building, located at 10 Aviation Way, is typically staffed by the manager and/or commissioners from 3:00-6:00 PM on Mondays, Thursdays, and Fridays, and 11:30 AM to 2:00 PM on Saturdays. This facility serves as an important resource for ensuring the safety of the airports users, encouragement of tourism, and for educational purposes. Constructed in 1996, the 786 ft^2 structure is heated by a natural gas-fired forced hot air system. During the warmer months, window AC units are used in the manager's office and main room. Although Montague is accountable for the facility and related utilities, the runway lighting electricity is not the town's responsibility.

Envelope

Review of the attic insulation indicated there are opportunities for envelope improvement. In certain areas, the attic lacks an ideal amount of insulation, and the ductwork responsible for supplying heated air is exposed outside of the envelope (**Figures 11 & 12**). The building does not have a basement, as it was constructed on a concrete slab.

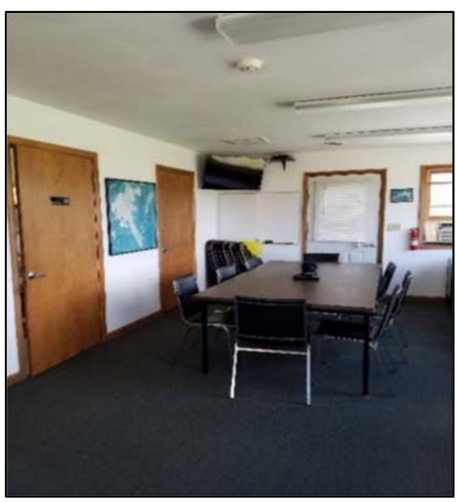


Figure 10. Airport Building Common Room Interior

Figure 11. Uninsulated Ductwork

Figure 12. Attic Insulation

Equipment Condition

The furnace (**Figure 13**), located in the attic, can be accessed via the airport communications-equipment storage room directly next to the manager's office. The furnace appears to be in good condition and properly sized.

Figure 13. Airport building furnace

Recommendations

Based on the information introduced above, CEE recommends that Montague explore and/or implement the following measures:

- Add insulation to areas with insufficient cover on the attic floor, and ensure all ductwork is properly covered. Montague should fabricate an insulated wooden box that can be placed over the furnace. The box can be easily removed for servicing, and can help improve efficiency, as the furnace would no longer be outside of the envelope (**Figure 13**).
- Install a remotely accessible thermostat (e.g., Nest or Ecobee).
- Replace main room (**Figure 10**) window AC unit with heat pump for cooling purposes; continue using window AC unit in Manager's office. The Town could also further explore de-commissioning the existing furnace system and using a mini-split for heating and cooling purposes year round.
- Replace all outside flood-lighting on airport building with efficient LED lights if not already done so.

3.2 Carnegie Library

This section (1) provides a general background of the Carnegie Library; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 5. Carnegie Library characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1912**	**7,056**	**Forced Hot Air**	**Oil**

Figure 15. View of Library from Avenue A

Figure 14. 1st Floor of Carnegie Library

Existing Conditions

Built from funds provided by the Carnegie Fund[6] in 1912, this historic building (**Figures 14 & 15**) is a heavily utilized public resource vital to Montague's Heritage. The 7,200 ft^2 structure provides a vast collection of resources and important programing for children of all ages and their families. The Carnegie Library is open from 1:00 – 8:00 PM on Monday, Tuesday, Wednesday; 1:00–5:00 PM on Thursdays and Fridays; and 10:00 PM – 2:00 PM on Saturdays.

The building's heating needs are supplied by an oil-fired forced hot air distribution system, paired with a five-ton condensing unit for cooling needs. Air-quality issues have been noted within the library, especially for employees working in the basement. Based on the findings of a state-conducted study, the employees have been advised against using the existing basement systems that circulate air as part of their operation. Aside from the inefficient heating and cooling systems discussed further on, high energy costs can in part be explained by the continual operation of multiple dehumidifiers to help mitigate air quality issues (**Figure 16)**.

The building's historical designation contributes to the difficulty of finding low-cost solutions for temperature regulation. For example, windows are important element for maintaining energy efficiency. Changing out and/or

[6] Andrew Carnegie was a Scottish immigrant who rose from a laborer to powerful steel entrepreneur in the 19th century. In 1901, Carnegie sold Carnegie Steel for $350 Million to J.P. Morgan (U.S. Steel). Carnegie was a controversial figure in his lifetime, and remains one—as he violently broke a union in what became a deadly armed conflict, fired hundreds of striking workers, increased hours and reduced pay at his mills, yet also donated upwards of $60 Million to fund a system of over 1,689 public libraries across the country.

improving windows is prohibitively expensive if done so in a way that complies with historical requirements. On the third floor, a few of the windows have been painted over and are inoperable. For the safety of the employees, new basement windows have been recently installed.

In compliance with the Americans with Disabilities Act (ADA), Montague had installed a concrete ramp to allow for mobility-impaired access. As indicated in a staff interview, during heavy precipitation events, water pools in the basement due to insufficient drainage around the ramp (**Figure 17**).

Montague has already allocated funds for replacement of the roof membrane and roof trim maintenance.

Figure 16. One of the many dehumidifiers utilized

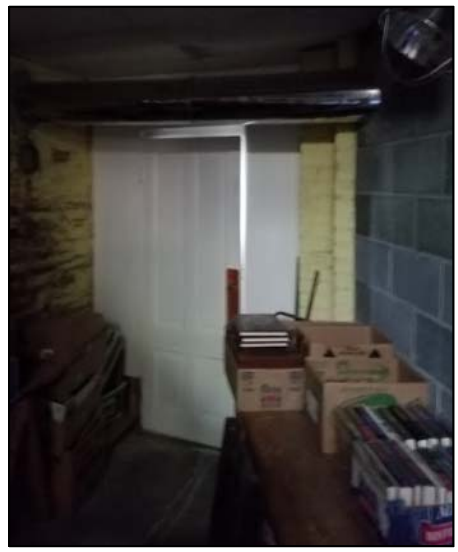


Figure 17. Area where water pools from ADA ramp

Envelope

CEE was unable to analyze the condition of the attic insulation. A potential areas from envelope improvements is the main entrance, which is neither heated nor cooled. Within this entranceway is a bathroom, main doorway to basement employee offices (**Figure 18**), and stairway to third floor. The main entranceway acts as an uninsulated stack, reducing delivery of conditioned air to the insulated portions of the building. The original double doors that from the entranceway into the 1st floor of the library are very drafty (**Figure 19**). To reduce the loss of conditioned air, these doors remain closed except when users walk through them. These doors are quite heavy and children often have fingers "pinched" by the doors.

Weather-stripping was introduced to the rear basement door entrance, but was subsequently removed because reducing fresh air exacerbated air-quality issues, especially indoor fumes resulting from the heating-oil combustion.

Figure 18. Doorway to employee offices in basement with large air gap

Figure 19. View of drafty double-door from main entranceway

Equipment

According to the B2Q Associates, Inc. Turnkey Replacement Proposal, the 10-year-old heating system is undersized and underperforming, with an estimated AFUE efficiency of 82% (**Figure 20**). The lack of heat and cooling power to the third floor, and poor temperature regulation throughout the building can in part be explained by the under sizing of the furnace and cooling unit. The consultants proposed replacing the existing furnace with two new propane-fired furnaces equipped with variable-speed blowers. Doing so will increase capacity by upwards of 20%, provide some redundancy, and allow the building to be split into different zones. Furthermore, each furnace will have its own 3.5-ton condensing units. To improve occupants' comfort, the consultants proposed the introduction of automated zone dampers, each paired with a programmable thermostat. Montague will move forward with the consultant's proposal using funding awarded 2017 Green Communities competitive grant cycle.

Figure 20. Current undersized boiler in Library

Recommendations

In addition to the ECMs funded by the 2017 GC grant and outlined in B2Q Associates, Inc. proposal, CEE recommends that Montague explore and/or implement the following:

- Conduct a comprehensive air-quality assessment that will review ventilation infrastructure for energy-conservation potential as well as the resolution of adverse health impacts.
- To reduce air 'stack-effect' within the south stairwell (connecting the basement to the 3rd floor) replace the existing 3rd-floor interior door with an airtight 'exterior' style door, as well as adding another exterior door at the first-floor landing.
- Once air quality issues have been addressed and documented, all exterior doors, as well as the main double-doors should be weather-stripped.
- Explore the introduction of window inserts[7] to help retain conditioned air.
- Montague should decide whether or not the main entranceway will be a conditioned space. Keeping the entranceway a non-conditioned space would require the doors shown in **Figure 19** to remain closed at all times and weather-stripped, thereby moving the envelope to the limits of the conditioned area.

[7] Interior window, or storm window inserts, are typically translucent insulation panels that are placed in the opening on the inside of existing windows to help reduce air infiltration. Window inserts can be used throughout the year to provide heating and cooling savings through improving the building's envelope and overall thermal efficiency.

3.3 Millers Falls Library

This section (1) provides a general background of the Millers Falls Library; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 6. Millers Falls Library characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1900**	**1,320**	**Hydronic**	**Oil**

Figure 21. View of Millers Falls Library from Bridge Street

Figure 23. Library interior, doorway demarcates original structure from the addition

Figure 22. View of Library from adjacent apartment seating area

Existing Conditions

The Millers Falls Library (**Figure 21**) is the smallest of Montague's three public libraries. Since its construction in 1900, an addition to the back of the structure has substantially increased its size (**Figure 22**). Currently, the Millers Falls Library is open from 2:00–7:00 PM on Tuesdays and Thursdays.

The original structure utilizes electric baseboard heating and is also heated by an oil-based hydronic system. During the day, the western-facing glass storefront receives a generous amount of solar gain. Although this is ideal during the heating season, in warmer months library staff typically close the blinds to reduce additional temperature increases. As a result, it may appear that the library is closed during regular business hours. To address warmer temperatures, the library is equipped with one air conditioner located near the middle of building. According to staff, the air conditioner does not move air effectively. Within the next five years, the roof will need to be replaced. Montague is aware of the building's structural issues.

Inspection of the open-earth basement indicates that the site suffers from water and moisture-management problems, as a stream runs directly under the property. Because of these issues, dehumidifiers are placed throughout the library.

Other envelope issues were observed in the dropped ceiling and with the book-drop (**Figure 24**) within the addition. The ceiling is adequately insulated; however, there is no visible air barrier in the examined section. Conditioned air escapes through the book-drop, especially when users open the slot. The once drafty windows in the addition have been retrofitted with window inserts to improve the envelope. According to the Director of Montague's Public Libraries, Linda Hickman, the Libraries hosted a public workshop to teach residents how to create their own "winderst".

Figure 25. View of library basement

Figure 24. Functional book drop indicated by red arrow.

Equipment Condition

The building is equipped with a Winkler oil boiler and Honeywell Controller (**Figure 27)**; various components have been replaced over the years. The building is also equipped with a hydronic unit heater located in the newer section of the building (**Figure 26**).

Recommendations

Based on the foregoing information, CEE recommends that Montague explore and/or implement the following:

Figure 27. Inadequate boiler with unused components

Figure 26. Hydronic unit heater

- Add air barrier to dropped ceiling, and additional insulation as required.
- Either decommission and seal the book drop, or create an insulated wooden structure that can cover the book drop from the inside to reduce loss of conditioned air. The structure should be easily removable to collect books.
- The existing boiler should be replaced with a condensing boiler or modern wood-heat boiler, and related smart system controls.
- To clearly establish the building envelope, the ceiling of the basement should be entirely insulated. As the boiler would still be outside of the envelope, a mechanical room should be erected. The framing of the mechanical-room wall should start two or so feet to the right of the boiler shown in **Figure 27**, and extend across to two feet past the left side of the stairway (**Figure 25**). Another section should be added to be flush against the retaining wall. The rest of the basement can be used for storage; a door should be installed in-line with the existing stairwell to connect the mechanical room with the basement. The interior door at the top of the stairwell leading to the basement should be replaced with an exterior-grade door.

3.4 Montague Center Library

This section (1) provides a general background of the Montague Center Library; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 7. Montague Center Library characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1800**	**2,700**	**Forced Hot Air**	**Oil**

Figure 30. Historic Town Hall sign on southern face

Figure 28. 1st floor Library Interior

Figure 29. 2nd floor historic gymnasium

Existing Conditions

The Montage Center Library (MCL) is an integral component of the Montague Center Historic District, listed on the National Register of Historic Places in 2001 by the National Park Service. This facility once served as the Town Hall (**Figure 30**) and contains a gymnasium on the second floor dating back to its original use and construction in 1800 (**Figure 29)**. MCL is open from 2:00 – 7:00 PM on Mondays and Wednesday. The building's heating demands are supplied by an oil-fired forced hot air distribution system. Domestic hot water is provided by a 6-gallon electric hot water heater in the basement.

During unoccupied hours during the heating season, the thermostat is set to 55 ˚F, with an operating temperature of 68˚F; the building is cooled to between 68 -70˚F by two window AC units on the first floor. Library staff are unable to run the dehumidifiers (to reduce mold and book damage), and AC at the same time, because of the building's outdated electrical infrastructure (**Figure 31**).

Historically, MCL has had the lowest electricity bills of the three libraries. As indicated in the Building Facilities spreadsheet provided by Montague, MCL requires some structural attention in addition to system alterations and improvements. On the east side of the building, water from the AC unit and rainfall collects in the brick façade, damaging the brick over time.

Figure 31. Conflicting electrical needs

Envelope

Previous equipment predating the current system likely contributes to loss of conditioned air. The original stairway entrance to gymnasium is not being utilized (**Figure 32)**; the exterior doors are in poor condition and missing weather-stripping. These conditions contribute to a large *stack effect*, creating a negative pressure that draws in unconditioned exterior air. Furthermore, the old HVAC system in the gymnasium has exterior ports that are another avenue for lost heat.

Figure 32. Exterior doors to gymnasium

During past energy retrofits, volunteers applied foam air sealing product to the underside of the 1st floor. This energy retrofit incorrectly altered the envelope by incorporating the uninsulated basemen as a part of the interior building envelope.

Equipment Condition

Although relatively new, the furnace is not properly sized for the building's heating needs and has been identified by Montague for eventual replacement. A new 350-gallon oil tank has recently been installed to supply fuel to the furnace. As previously noted, if the basement was intended to be outside the conditioned envelope, the absence of insulation on the ductwork reduces the efficiency of the furnace.

Recommendations

Based on the foregoing information, CEE recommends that Montague further explore and/or implement the following:

Figure 33. Open-earth basement and proposed alterations.

- Un-utilized heating infrastructure, such as gymnasium exterior ports, should be properly decommissioned and sealed to limit air loss and improve envelope integrity.
- Montague should consider implementing electrical infrastructure retrofits as recommended by future audits.
- All doors should be properly weather stripped and/or restored as applicable.
- To reduce air stack effect, the doors indicated in **Figure 32** should be framed in by an insulated structure to avoid loss of conditioned air, and another structure should be place at the top of the stairwell in front of the doors to the gym. In case of emergency, these structures should be designed to be easy to knock over.
- When the furnace is replaced, CEE has identified two potential options:
    - Replace oil-fired with high efficiency propane-fired furnace, or mini-split heat pumps, and move distribution system upstairs to available location. To exclude the basement from the envelope, the basement ceiling should be insulated, and equipped with an air barrier and vapor retarder. Remaining ductwork should be heavily insulated or brought within the envelope.
    - Add an air barrier, insulate ceiling and around ductwork, and introduce vapor retarder to entire area outside new envelope as discussed. As shown in **Figure 33,** install vertical insulated wooden barrier where the open-earth basement is held back by retaining walls on both sides of the basement to

redefine the envelope. Drainage trenches and piping on the outside of new envelope will help mitigate bulk-water management issues. If the basement were ‘framed in’ as discussed above, the furnace would be inside the envelope.

3.5 Hillcrest Elementary School

This section (1) provides a general background of the Hillcrest Elementary School; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 8. Hillcrest Elementary School characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague (Utilities Responsibility of GMRSD)	**1958**	**15,332**	**Steam**	**Oil**

Existing Conditions

Figure 34. Hillcrest Elementary School mural

Designed by a famous architect Bernhard Dirks, the Hillcrest Elementary School (Hillcrest) within the Village of Tuners Falls was erected in 1958. Although Hillcrest is operated by the Gill-Montague Regional School District (GMRSD), the building is owned and maintained by the Town of Montague. Hillcrest is currently utilized by roughly 350 students and staff. During the academic school year, the main operation hours are from 8:30 A.M. – 3:15 P.M. The school is heated by a pneumatic-controlled oil-fired steam heating system (**Figure 35**), with a set point between 68 – 72 ˚ F. For domestic hot water, the building relies on a stand-alone oil-fired 35-gallon hot water tank. Eversource has conducted an electrical audit; 2017 Green Communities grant funding has been earmarked for LED lighting upgrades and replacements.

Figure 35. Steam distribution system infrastructure

Envelope

In efforts to improve the building's efficiency, a significant number of windows have been replaced. Based on the design, the skylights have been more difficult to find suitable replacements. There are old passive vent structures in the building that are used for fresh air circulation within the building. These unused systems now act as channels for cold air and should be air-sealed and insulated at both entry and exit points if they will remain unused.

Equipment

Typical of steam systems in areas with hard water[8], Hillcrest's distribution piping infrastructure has been seriously degraded, leading to costly piping replacements. As pipes corrode, large holes are created throughout the system as well as significant build-up in the pipes (**Figure 36**). Furthermore, the hard water contributes to the need for extensive valve maintenance.

Figure 36. Removed piece of piping form Hillcrest illustrating impact of hard water.

Currently, the original boiler is leaking in two sections on the service side. A repair estimate of $2,000 per section was provided to the School District's Facilities Manager. As indicated by the facilities manager, the air drier for the steam distribution system will need to be replaced in the near future.

Additionally, the current electrical configuration is outdated and problematic. The building's electrical feed enters the school building without passing through an exterior junction box. During significant precipitation events, live feeds are submerged underwater. One previous estimate for upgrading the electrical infrastructure was roughly $80,000. The introduction of a more powerful system (i.e., 800 amps) would allow for the use of individual AC units within the classrooms.

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- Move forward with electrical retrofit recommendations indicated by previous audit introduced above.
- Repair the two damaged sections of the boiler. At the end of the current boilers lifespan, replace with a compatible modern wood heating[9] steam boiler.
- Within mechanical room, insulate ductwork and seal the open access area.
- Air seal and insulate existing passive ventilation system at all interior openings within the building.
- Update HVAC controls (i.e., pneumatic controls) or install high efficiency compressor for existing system.

[8] Hard water is high in dissolved in minerals, both calcium and magnesium. The presence of hard water is prevalent in the eastern United States, a result of the distribution of carbonate aquifers and aquifers with relatively high concentrations of dissolved solids. When heated these minerals precipitate from the water and encrust themselves to related infrastructure.
[9] See Appendix C for detailed explanation.

3.6 Sheffield Elementary School

This section (1) provides a general background of the Sheffield Elementary School; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 9. Sheffield Elementary School characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague (Utilities Responsibility of GMRSD)	**1904**	**35,000**	**Forced Hot Water & Steam**	**Oil & Natural Gas**

Existing Conditions

Located in the Village of Turners Falls, the Sheffield Elementary School was constructed in the 1930s, with major renovations taking place in 1988 after the school had burned in a fire. During the academic school year, the building is open Monday through Friday 8:30 AM – 3:15 PM, not including extracurricular activities. The two-story brick building, including the gymnasium, Sheffield administration building, and auditorium is the largest town-owned public building at 95,000 ft^2. As with the Hillcrest Elementary school, the GMRSD is responsible for utility costs, while the town is responsible for capital facility needs.

Figure 37. View of Sheffield Auditorium from balcony area with original 1930s seating.

The Sheffield School is heated by a natural-gas-fired hydronic distribution and oil-fired steam system. Hot water is provided by two natural-gas fired hot water heaters. For cooling needs within the classroom, AC window units can be supported by the upgraded Siemens electrical panels. Each classroom is served by a single-unit ventilator that runs 24/7. The ventilators provide a constant source of fresh air through outside air dampers.

The boiler-generated steam is either used directly by steam radiators located in the gymnasium and auditorium (**Figure 38**), or converted to hot water via a steam-to-hot-water heat exchanger. Heating hot water is supplied to the classroom unit ventilators, hallway convectors, and baseboard radiation systems located in the cafeteria.

Figure 38. Auditorium radiator in balcony

Funded by a Municipal Energy Technical Assistant Grant (META) through DOER, an ASHRE Level II audit was conducted by in 2017 by Sebesta. As indicated in Montague's 2017 Green Community Grant Application Narrative, Montague will be pursuing four Energy Conservation Measures (ECM) as recommended by the Level II audit, providing an estimated savings of $13,850 less than the school's annual utility costs of $89,941.

These ECMs include:

- ECM #1 recommission hot water pumps
- ECM #2 install light occupancy Sensors
- ECM #3 Replace the library rooftop HVAC unit
- ECM #4 replace the cafeteria rooftop HVAC unit

Those four ECM's would be leveraged by other ECMs that the School district has committed to implementing and completing by the time the grant closes as introduced below:

- ECM #5 upgrade water fixtures
- ECM #6 upgrade lighting
- ECM#7 domestic hot water timer

Envelope

The gymnasium windows were replaced with Low A/E glazed window panels; however, during this replacement, no additional insulation or foam was added in between the wall and brick façade. Within the last year, Montague invested over $900,000 into the Massachusetts School Building Authority (MSBA) Repair Program for the window project. Exhaust vents throughout the entire building dispel conditioned air, creating a stacking effect within the auditorium.

Equipment

Two sections of the gas boiler have been removed so that it runs at a higher efficiency (around 2 Million BTUs). The gas-fired boiler was initially the back-up of the two, but has recently been the more utilized distribution system due to oil costs. Jim Huber, the School District facility manger would like to see the steam distribution system removed from the school. Similarly, the two gas-fired 89-gallon hot water tanks are in need of replacement. Hot water is distributed by two five-horsepower pumps controlled by variable speed drives, one of the pumps was noted to always run at 100% speed and needs to be replaced. The building is also equipped with two make-up air units to condition air in the library and kitchen. As discussed in the Level II audit, the kitchen make-up air runs whenever the kitchen hood is switched on; the gas heat element of this air-handler is no longer functional. Both the cafeteria and office areas are served by the original 1988 roof top units (RTU), and are considered to be "well past their use life" according to Sebesta Inc.

Recommendations

In addition to the ECMs identify by Sebesta, Inc. CEE recommends that Montague further explore and/or implement the following:

- Retrofit Motion detectors installed with 2017 Green Communities funding to control heating in addition existing lighting function.
- Introduce large fan (e.g., "Big Ass Fan" brand) in the center of the auditorium to help de-stratify stacked building heat within the auditorium.
- Install motorized dampers and/or seal and insulate building passive exhaust vents to reduce loss of conditioned air.
- Discuss potential community alternative uses for auditorium during non-school hours.
- Conduct envelope audit.

3.6.1 Sheffield Administration Building

This section (1) provides a general background of the Sheffield Administration Building; (2) discusses key observations; and (3) identifies areas of opportunity for improved energy efficiency.

Existing Conditions

Although outside the scope of this study, it is important to briefly introduce the GMRSD's Administration Building. The 16,080 ft^2 structure built in 1935 is attached to the Sheffield Elementary School. Currently the building houses between 25 and 30 full-time occupants. Equipped with a professional development lab, the building is frequently utilized for internal and external training purposes.

The building's heating demands are supplied by an oil-fired hydronic steam system. The boiler is supplied by a 10,000 gallon single-walled steel tank (SWST). The boiler itself is in good condition but, as with the Hillcrest School, the aging stem pipe infrastructure has been problematic. Historically, the building's structural issues have taken priority. The rotted barrel columns and portico issues on the northwest entrance of the building will require immediate attention to reduce further decay.

Recommendations

Although window replacement can be costly, we recommend that at a minimum, Montague further consider replacing the windows within the building as they are far past their lifespan. Considering the extensive damage of window components, repairing would likely be non-cost-effective. Unless funds are allocated to the replacement of windows in the administration building, further investment for ECMs would likely be significantly less effective. Within the mechanical room, air sealing of all gaps and weatherization of the doors should take place. The brick on the northern side of the building has deteriorated due to freeze-thaw cycles.[10] Further bulk-water management efforts and structural repairs should help mitigate this issue.

[10] Freeze-thaw damage occurs when a porous material has absorbed water before the temperature drops below freezing. The expanding of the water within the brick contributes to its deterioration.

3.7 Montague Public Safety Complex (Police Station)

This section (1) provides a general background of the Public Safety Complex; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 10. Montague Public Safety Complex characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague (Police Station only)	**2008**	**10,685**	**Ground Source Heat Pump**	**Electricity**

Figure 39. View of Public Safety Complex from Turnpike Road

Existing Conditions

With concerns about rising fuel prices and climate-change related issues, the construction of LEED-Designed Public Safety Complex in 2008 demonstrated a significant interest in the energy field within Montague. Asides from the Regional Fire District and Police Station, the Public Safety Complex also houses a Community Room, frequently used for presentations and training opportunities. Although the Police Station is directly attached to the Turners Fire Department, the fire station constructed in 1975 is under the jurisdiction of the local Fire District established under MGL Chapter 48, Sections 60-80. As a result, the fire station is not included within Montague's Green Communities energy baseline. The building is heated and cooled by a ground source heat pump (GSHP) system (**Figure 40**), this is unique among Montague's facilities. These systems are frequently referred incorrectly as a "geothermal systems" in the New England region.[11]

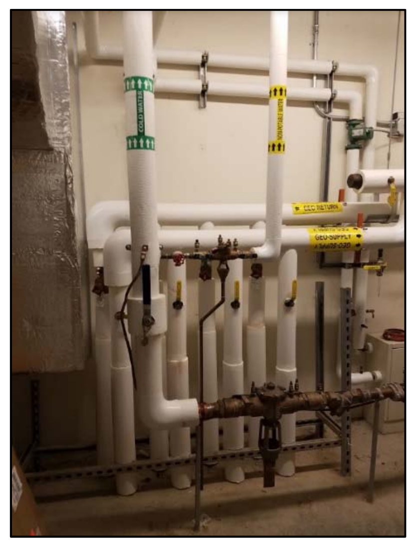


Figure 40. Ground source HVAC system

[11] Although both ground-source (GS) energy, and geothermal systems utilize the Earth's ground temperature to help generate electricity, there are significant differences. In GS systems, energy is recycled using a ground-coupled heat exchanger (piping underground), a heat pump, and distribution system to circulate conditioned air areas throughout the building. True geothermal energy solely uses heat from deep within the earth's core, these systems do not require a heat pump or 'looped' systems. Geothermal systems are limited to areas in close proximity to tectonic plate boundaries (volcanic activity close to the surface).

Envelope

The facility's envelope is in good condition. The uninsulated roof access hatch appears to be an area of opportunity for additional insulations efforts in the police station (**Figure 41**). CEE was unable to review the condition of the building's insulation during the scheduled visit.

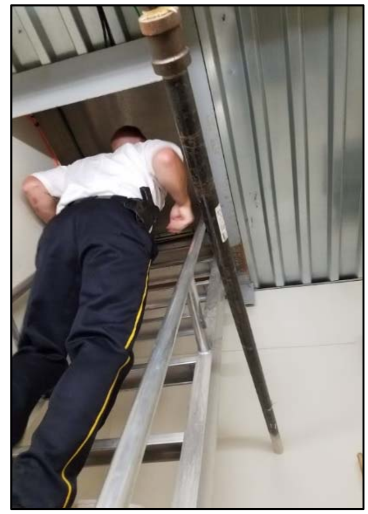


Figure 41. Former police chief Chip Dodge Climbing roof access hatch

Equipment

Discussions with the Public Safety Complex administrative staff indicated that the GSHP system has not functioned as intended. The system was designed to provide heating and cooling services to occupied rooms as indicated by installed motion sensors. However, due to insufficient and irregular temperature regulation throughout the building, the motion detection function has since been disabled. Running the system 24 hours a day, seven days a week, has made a noticeable difference in terms of distribution consistency and temperature regulation across the facility. It was suggested by service technicians that lower-quality installed ductwork during the construction of the complex contributes to distribution issues. The building is also equipped with a rooftop unit (RTU) air handler that provides ventilation to the building. On the west side of the building there is a diesel powered generator that has been recently serviced (**Figure 42)**.

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- The building could greatly benefit from the establishment of HVAC controls to manage occupied hours and set points.
- The orientation and large surface area of the roof makes it a prime candidate for a PV system; however, the structural capacity of the roof should be further investigated. The introduction of a PV system would help to offset the facility's large electrical consumption. Based on the information provided to CEE it is unclear whether the Fire Department and Fire Station are on separate electrical accounts. If not, the buildings should be separately metered.
- Insulate the roof access hatch as indicated in **Figure 41.**

Figure 42. Public Safety Complex diesel generator

3.8 Montague Senior Center

This section (1) provides a general background of the Montague Senior Center; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 11. Montague Senior Center characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1890**	**1,658**	**Hydronic**	**Natural Gas**

Figure 43. Workers from Franklin County Sheriff's Department repaint Gill-Montague Senior Center (Miranda Davis)

Figure 44. Senior Center basement full-kitchen

Figure 45. AC units on western side of building

The Montague Senior Center (**Figure 43**) strives to enhance the quality of life for seniors in the community by providing health, education, recreation programs, and activities free of charge for residents 55 years of age or older. Although the building has not seen major alterations from its 1890 construction, some of the interior has since been refinished and modified to help promote its programming. The hours of operation depend on the provided programing, although most of which held Monday through Friday. The facility is heated by a natural gas-fired hydronic distribution system, and cooled via wall AC units (**Figure 45**). Upstairs, the boiler feeds two hydronic unit heaters. These heaters are ideal for buildings with large open areas and low ceilings, countering heat loss along outside walls, especially where windows are present (**Figure 47**).

The facility is also equipped with a full kitchen (**Figure 44**) in the basement that generates a significant amount of heat from the equipment and gas stove pilots running throughout the day and night. Domestic hot water needs are supplied by a free-standing electric hot water tank.

Envelope

CEE was unable to review the condition of the insulation at the time of the inventory walk-through. Facility staff haven't noticed the dumbwaiter contributing cold air into the activity space during the winter months (**Figure 47**). Due to the position of the boiler, it is unclear whether or not it's inside the building envelope. Heating related piping infrastructure found outside the envelope lacks proper insulation within the boiler room (**Figure 46**).

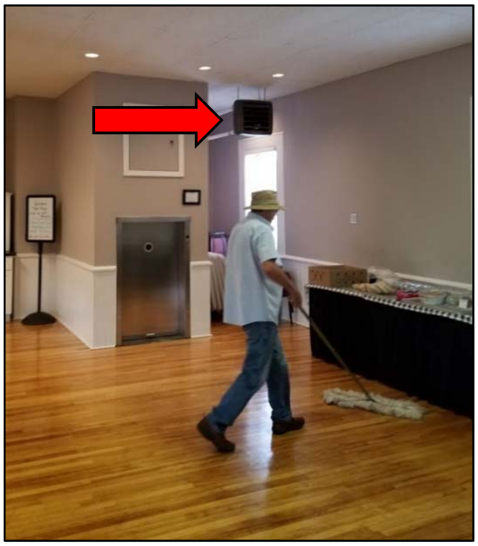


Figure 47. One of two hydronic heating units in main activity room

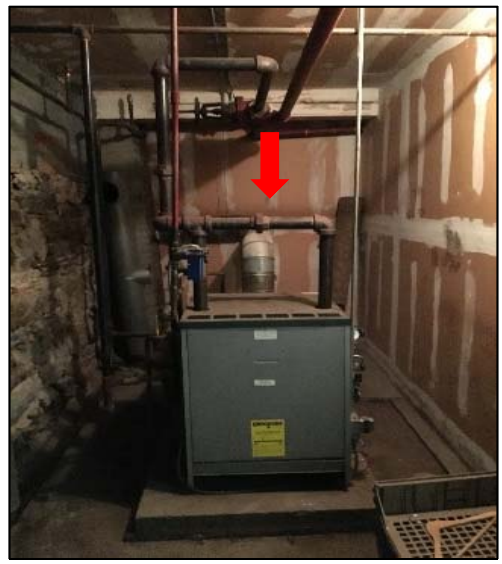


Figure 46. Boiler room

Equipment

The boiler was recently serviced prior to the 2016 heating season. The heating distribution system is controlled by a Nest Thermostat (**Figure 48**), which can be controlled remotely via a smartphone app or internet connection.

Figure 48. Remotely adjustable thermostat

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- Install an ECM[12] motor in fridge if not already equipped with one.
- Further explore the feasibility of utilizing excess heat created by the fridge and stove in the basement to replace domestic hot water needs via an air-source heat pump.
- Insulate all exposed piping infrastructure indicated in **Figure 46**, or frame mount and insulate the building's original foundation (left wall of **Figure 46**) to include the boiler room within the building envelope.

[12] Electronically Commutated Motors (ECM) regulates their own speed, leading to increased energy savings.

3.9 Montague Hall

This section (1) provides a general background of the Town Hall; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 12. Town Hall characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1880**	**13,000**	**Hydronic**	**Natural Gas**

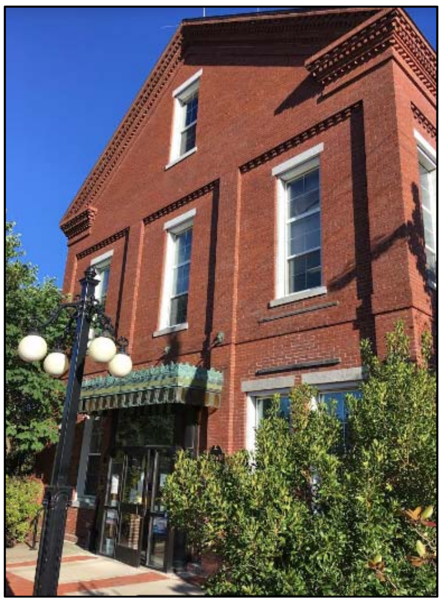


Figure 51. View of Town Hall from Avenue A

Figure 50. View of boiler room

Figure 49. Hydronic Boiler System

Located adjacent to the Gill-Montague Bridge on Avenue A in Turners Falls, Montague's Town Hall (**Figure 51**) is another example of the Village's rich architectural history within the nationally recognized Tuners Falls Historic District. The 13,000 ft^2 building's heating needs are supplied by a recently installed natural gas-fired hydronic distribution system housed in the boiler room (**Figure 50**). Domestic hot water is supplied by a natural gas-fired hot water heater. Hydronic unit heaters are scattered throughout the basement. As identified by Montague, the roof has been scheduled for replacement by 2017.

Envelope

The largest envelope improvement opportunities noticed during the walk-through pertained to the attic and basement. Within the attic, there appeared to be no evidence of an air barrier. Visible light from the second floor could be seen through the uninsulated light fixtures in the attic floor. Both the ductwork circulating conditioned air and the attic floor lack adequate insulation in certain areas. CEE was not able to inspect the attic space above the level indicated in **Figure 52.** Therefore, the true thermal envelope is therefore unclear.

Figure 52. Condition of attic insulation

Furthermore, other prominent envelope and air sealing issues were observed throughout the basement. Particularly, these opportunities were most prominent in the bike storage room. Gaps in the wall of the storage room (**Figure 53**), among others (**Figure 55**) allow conditioned air to be disbursed throughout the building or expelled from the building directly. For example, conditioned air is lost through the leaky generator room exhaust infrastructure (**Figure 54**).

Figure 55. Additional wall gaps in basement

Figure 54. Air vent in generator room

Figure 53. Gaps in bike storage room

Equipment Condition

The building's heating and cooling needs are currently controlled by a remotely accessible Ecobee thermostat. The recently installed hydronic distribution systems includes two 350,000 BTU condensing boilers and a 200-liter natural gas-fire domestic hot water heater (**Figure 56**). Currently the system is not equipped with variable frequency drives (VFDs) for the distribution pumps.

Figure 56.VIESSMANN indirect fired domestic hot water storage tank

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- Add VFDs to hot water distribution pumps in mechanical room.
- The large surface area over the basement and maintenance area is an ideal location for PV system to help offset the building's high electricity consumption. The town should further review and coordinate potential solar design and system with the construction of the new roof.
- As CEE was unable to gain access to the space above the attic illustrated in **Figure 52**, it is unclear as to where the true thermal envelope of the building lies. If indeed the space shown in **Figure 52** demarcates the envelope, additional insulation should be added and redistributed throughout the attic to increase the overall R-value. CEE especially recommends air sealing and additional insulation around the perimeter of the attic.
- Air gaps throughout the basement should be sealed (**Figures 53 & 55)** as well as insulating envelope gaps in the generator room (**Figure 54)**.

3.10 The Shea Theater

This section (1) provides a general background of the Shea Theater; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 13. Shea Theater characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1928**	**11,440**	**Forced Hot Air**	**Natural Gas**

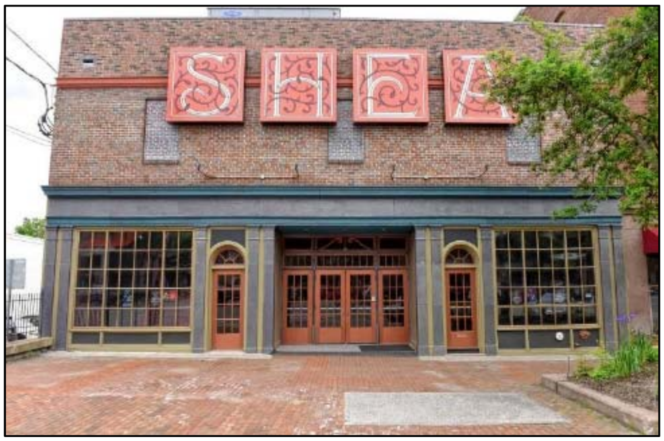


Figure 58. View of Shea Theater from Avenue A

Figure 57. Renovated Shea Theater Interior

Existing Conditions

Montague acquired The Shea Theater (**Figures 57 & 58**) from the Franklin County Development Corporation (FCCDC). Under the Massachusetts Commercial Homesteading Act, the building is rented to the Shea Community Theater, a non-profit organization for $1.00 annually. The historically significant, 11,440 ft^2 building was constructed in 1928 and is heavily utilized. The facility is referred to today as the Shea Theater Arts Center. Asides from capital improvements, the tenant is responsible for heating, cooling, and electricity consumption costs. In 2016, the town of Montague replaced the previous 27 year old packaged RTU unit with a new efficient two phase natural gas-fired heating and cooling system (**Figure 59**). B2Q consultants had also suggested that the town replace the ductwork, but was not economically feasible during the installation of the RTU. The building is also equipped with electric baseboard heating in the basement.

Figure 59. Recently installed two-phase Carrier HVAC System

Envelope

CEE was unable to review the condition of the insulation of the Shea during the walk-through. As indicated by Montague, the facility will not undergo any insulation upgrades during the roof replacement in the Fall of 2017. The Facility could benefit from improved weatherization such as weather stripping on poorly sealed doors as reflected in a side entranceway of the theater (**Figure 60**), as well as properly insulated and air sealed closures to the existing passive vent system during the winter season (**Figure 61**).

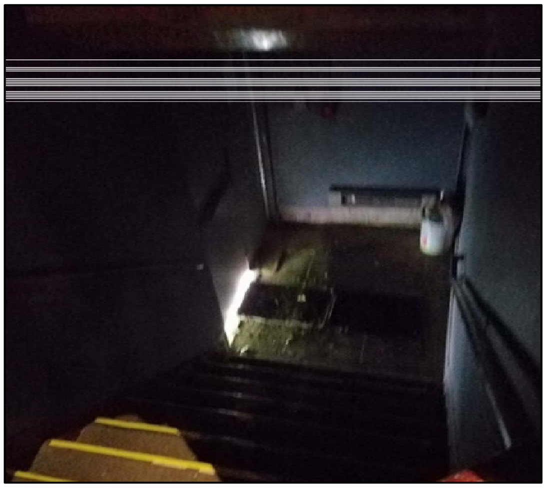


Figure 60. Large air gap under theater side entranceway

Figure 61. Theater vent infrastructure

Equipment

Using Green Community Grant funds secured in FY 2017, as well as capital funds, Montague will replace compromised ductwork (**Figure 62**) discovered during the installation of the new RTU. Replacement of the inefficient ductwork will improve the HVAC performance by reducing fan static, increasing airflow, and improved CO2 control. The work is expected to be completed by the spring of 2018. In all, the project should expect to provide an annual cost savings of $1,846 annually, and reduce the facility's consumption by 14.2 percent.

Reccomendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- Weatherization improvements such as weather stripping of doors (**Figure 60**).
- Ensure theater ventilation infrastrucutre is insulated and/or capped during the heating season to reduce loss of conditioned air.

Figure 62. Original HVAC ductwork scheduled for replacement

3.11 The Colle Building

This section (1) provides a general background of the Colle Building; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 14. Colle Building characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague (Utilities responsibility of tenant)	**1900**	**14,440**	**Forced Hot Air** (Separate Units)	**Natural Gas**

Figure 64. View of Colle Building from Avenue A

Figure 63. Ten separate units on Colle Building rooftop

Existing Conditions

At the turn of the century, the Colle Opera House (a Vaudeville-era theatre) was the chief source of entertainment within the Village of Turners Falls (**Figure 64)**. Originally constructed in 1874, the Colle Opera House (the Colle Building) was heavily restored during the early 2000s as Montague undertook a large number of adaptive reuse projects of surviving 19th century architecture. Today, the Colle Building serves as office space for Center for Responsive Schools (CRS), a non-profit educational organization. As of 2017, CRS has been a tenant for roughly seven years; a special revenue fund has been created for capital project needs related to the building.

With the exception of the main hallway lighting, the costs of heating, cooling, and electricity are the tenant's responsibility. The building is cooled and heated via a forced hot air distribution system with ten separate units, with respective condensers on the roof controlling different zones within the building (**Figures 63** & **67**).

Envelope

A brief review of the Colle's roof envelope confirmed the absence of an air barrier and inadequate amount and/or placement of insulation for optimal energy efficiency (**Figure 66**). There are significant air gaps and varying levels of insulation quality, as shown by the exterior light entering the building in (**Figure 65**). The access hatch to the roof is also uninsulated. Several sections of ductwork are exposed with deteriorated or penetrated insulation. Spray foam has been applied to the rafters in one section above the insulation. Although this acts as an air barrier, it is in the incorrect location as it does not stop air from wind washing the insulation below it.

Figure 66. Roof insulation configuration

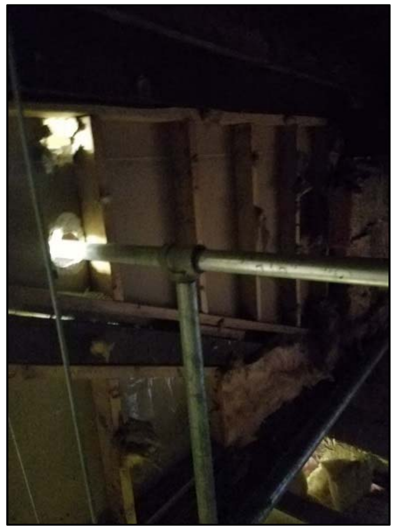


Figure 65. Visible light through insulation

Equipment

The building's ten individual gas-fired furnaces appeared to be in good condition. For the current tenant, the configuration of the distribution systems appears to adequately serve the needs of the organization. Clearly mapping out the location of each mechanical closet and respective heating/cooling zones in an easily digestible format may help users better understand and regulate consumption.

Figure 67. One of 10 Individual furnaces

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- The envelope would benefit from ensuring that existing insulation (**Figure 66**) is distributed evenly, or added too in areas insufficient coverage.
- Increase air sealing of envelope in the attic (**Figure 65**).

CEE was requested by the town to provide recommendations based on two distinct building occupancy configurations as they relate to the heating system design: single tenant occupancy and multiple tenant occupancy. A decentralized heating system, which would be suited to a multiple-tenant occupant scenario provides controllability and higher efficiency as the system will be operating closer to capacity than a centralized system when supplying heat to only one zone. However, a centralized system would be able to operate at a higher efficiency for a fully occupied, single-tenant building. Therefore, if the town decides to have the building occupied by multiple tenants, Montague should keep the decentralized heating systems. If the current tenants move out and the building is fully occupied, at that point Montague should consider installing a centralized heating system to supply all of the building's heating demands.

3.12 Water Pollution Control Facility (WPCF)

This section (1) provide a general background of the Water Pollution Control Facility; (2) discusses key observations pertaining to the condition of the facility's envelope and equipment; and (3) identifies areas of opportunity for improved energy efficiency.

Table 15. Water Pollution Control Facility characteristics

Building Ownership	Year of Construction	Gross Area (ft2)	Distribution System	Fuel Source
Town of Montague	**1964**	**16,000**	**Hydronic**	**Oil**

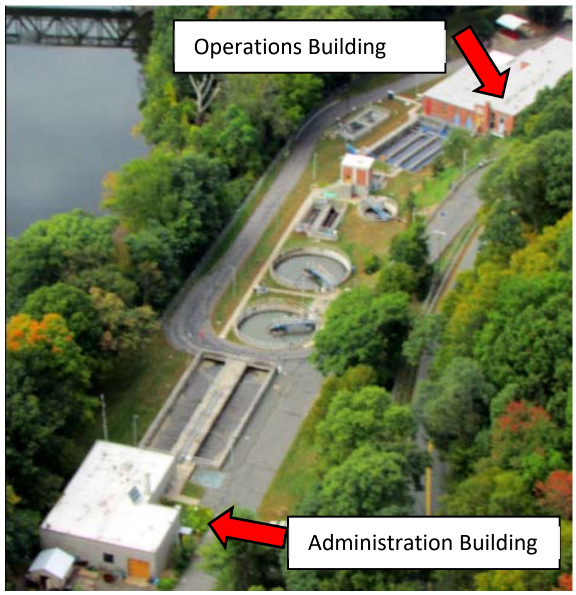


Figure 68. Aerial view of WPCF

Existing Conditions

Montague's Water Pollution Control Facility (WPCF) was originally built in 1962, and upgraded in 1982 and 2010 (**Figure 68**). The WPCF is responsible for the operation of the treatment facility, in addition to eight (8) pump stations, and respective force mains. The facility treats domestic, commercial, and residential waste from the five villages: Turners Falls, Montague City, Montague Center, and Lake Pleasant. In 2010, the WPCF received one of three Environmental Protection Agency Excellence Awards distributed in EPA's Region I. The WPCF is currently engaged in a unique pilot program where blackwater is treated with bacteria and oxygen control to eliminate all solid sewage. Although this facility has been included within CEE's inventory, operation-specific infrastructure recommendations and overall plant condition will be best addressed by the WPCF Superintendent, Robert MacDonald.

Typically, the building is occupied from 6:00 AM to 4:00 PM Monday through Friday, and 6:00 AM to 10:00 AM on Saturday and Sunday. The WPCF is comprised of two buildings: The Administration Building & Operations Building. Each building is heated by oil-fired hydronic distribution system. The Administration Building's domestic hot water needs are supplemented by a solar hot system.

As discussed in Siemens' preliminary investment grade audit, the WPCF was identified as a significant area for energy reduction.

Envelope

In 2012, Montague requested $80,272 in grant funding to implement four ECMs, part of the budget was requested for weatherization projects, yet it seems that these projects were not funded. If that is the case, Montague should move forward with envelope improvements originally suggested in the 2012 ESCO report.

Equipment

The Operations Building boiler is believed to be the original since the initial construction. The current Administration Building boiler was installed in 2006. The facility is equipped with a large back-up generator; within the generator room there is also a large exhaust fan. The administrative offices are cooled via window AC Units. According to the Superintendent, the blowers consume the largest amount of energy and are nearing the end of their lifespan.

Recommendations

Based on the information introduced above, CEE recommends that Montague further explore and/or implement the following:

- Consider replacing the original boiler in the Operations Building with a modern wood heat system or high efficiency condensing boiler. Any boiler replacement would warrant upgrading the control systems.
- Investigate WWTP specific energy efficiency opportunities identified in **Appendix A.**
- Investigate the replacement of AC window units with mini-splits.

3.13 Proposed DPW Facility

This section (1) provides a general background of the DPW Facility; (2) discusses key observations pertaining to the condition of the facility; and (3) identifies areas of opportunity for improved energy efficiency within the proposed facility.

Figure 70. View of DPW facility

Figure 69. Outside storage of DPW equipment

Existing Conditions

The 1948 DPW facility (**Figure 70**) no longer is able to accommodate Montague's vehicle fleet and related equipment. Vehicles currently have to be parked with equipment in close proximity of each other to fit with the building. Similarly, the vehicle maintenance area is undersized, inefficient, and unsafe as equipment cannot be properly raised for maintenance. Furthermore, the building's small footprint requires components of the fleet (i.e., snow plows) to be stored outside (**Figure 69**), affecting the life expectancy of the equipment and operations logistics. The building is currently non-compliant with current building, plumbing, and mechanical code.

Proposed Design

Figure 71. Rendering of new facility

The Town of Montague has proposed the construction of a new 27,000 ft^2 pre-engineered metal building on land owned by the town located off Sandy Lane (**Figures 71** & **72**).

Figure 72. Conceptual floor plan

Recommendations

Highway garages and public works buildings have typically been flagged for major energy efficiency opportunities in CEE's Municipal Energy Assessments. Commonly observed issues stem from temperature regulation and stratification issues caused by the constant opening and closing of large overhead doors, high electrical demands from equipment, HVAC set points, building scheduling and operations, as well as the need to heat and/or cool large structures. Based on the facility background provided by the town, CEE recommends that Montague consider the following technologies and practices moving forward for this structure:

- Further explore clean heating technologies as discussed **Section 6**. The building's heating needs could be supported by individual systems such as a GSHP, a modern wood heating boiler, and/or radiant floor heating for the garage areas.
- Based on the facility rendering and orientation, the roof has tremendous potential for a PV system to help offset energy costs.

3.14 Municipal Streetscape Lighting

This section (1) provides a general background of Montague's streetscape lighting; and (2) identifies areas of opportunity for improved energy efficiency.

As indicated by Montague officials, the Town has already replaced traditional streetscape lighting with efficient LED lighting in Turners Falls. Downtown Millers Falls is the other village within the Montague that has streetscape lighting. When funds permit, replacement of traditional bulbs with LEDs is recommended. For all other overhead street lighting infrastructure, typically owned by utility companies, Montague should contact its representative to discuss Eversource's consideration of selling the lighting infrastructure to the town. Over the long run, purchasing and converting traditional bulbs to LED may save more money than paying the utility companies. However, utility companies may try to sell the infrastructure for prohibitively high costs, thereby deterring the sale altogether.

3.15 Sewer Pump Stations & Force Mains

This section (1) provide a general background of Montague's wastewater infrastructure; and (2) identifies areas of opportunity for improved energy efficiency.

CEE was unable to review the condition of the Montague's sewer infrastructure. Two of the existing eight pump stations have recently been replaced as indicated by town officials. In general, strategies for lowering pump energy consumption include (1) replacing throttling valves with newer controls, (2) reducing speeds for fixed loads, and (3) installing parallel systems for highly variable loads.

3.16 Single-walled Steel Fuel Oil Tanks

This section (1) provides a general background of Montague's single-walled steel fuel storage infrastructure; (2) identifies resources for further exploration by Montague; and (3) discusses projected costs for complying with state regulations.

The walk-throughs highlighted an important MassDEP compliance issue pertaining to GMRSD's fuel oil storage systems. Promulgated under 310 CMR 80.15, all single-walled steel tanks (SWST) must be taken "out of service" by August 7, 2017. MassDEP is exercising enforcement discretion to grant extensions of that deadline until July 1, 2018, to owners who satisfy certain criteria discussed on their website (http://www.mass.gov/eea/agencies/massdep/toxics/ust/single-walled-steel-tank-requirements.html). The GMRSD's distribution systems currently depends on three 10,000-gallon SWSTs to store fuel oil. The ages of these tanks are estimated to be around 70 years-old. As discussed by the facilities manager, costs to replace these tanks is upwards of $250,000. As such, additional costs for disconnecting and installing new infrastructure may lend itself to replacing GMRSD's fuel oil consuming infrastructure with alternative technologies such as modern wood heat wood pellet boilers, or other highly efficient propane-based systems.

4. Building Energy Analysis

4.1 Summary of Key Building Performance Metrics

To better understand building operations and make informed decisions regarding energy investments, the tools discussed in **Section 2.3** were applied to all the key buildings and shown in **Table 16**. Key buildings are defined as having a high overall energy consumption relative to the other municipal buildings within Montague. Together, these buildings comprise approximately 80-90% of the total municipal building energy use, and are therefore critical to achieving energy reduction goals. The full background analysis is included in **Appendix C**.

Table 16. Summary of key building energy consumption and performance metrics

Building Name	Energy Consumption* (MMBtu)	Energy Use Intensity* (kBtu/ft^2)	Heating Performance (Balance Point °F)
High Priority			
Sheffield Elementary School	5,152	147	-
Key Interpretations: The Sheffield Elementary School has both the highest overall energy consumption and *energy use intensity* (i.e., energy consumption per square foot of conditioned space). The school has the highest heating fuel consumption and the second highest electricity consumption. Heating fuel accounts for 83% of the building's energy consumption. Montague should identify the Sheffield Elementary School a **high priority** for thermal and electrical assessments.			
Hillcrest Elementary School	2,479	162	-
Key Interpretations: The Hillcrest Elementary School has the second highest level of heating fuel consumption, as well as a relatively high energy intensity. Montague should identify the Hillcrest Elementary School as a **high priority** for thermal assessments.			
Police Department	1,523	143	-
Key Interpretations: The Police Department consumes a large amount of both electrical and thermal energy. The building has the second highest energy intensity of all buildings examined. Due to the identified low cost ECMs, the Police Department should be considered as a **high priority**.			
Town Hall	1,127	87	65
Key Interpretations: The Town Hall is a large energy consumer and has a relatively average energy intensity. Overall, the Town Hall has the third highest electric and heating fuel consumption. Montague should place a **high priority** on envelope and electrical assessments for the Town Hall.			

Carnegie Library	265	98	65
Key Interpretations: The Carnegie Library has a relatively low energy consumption level and a high energy intensity. Due to its low energy usage, any improvements to this building will have a lower impact to overall municipal consumption than the other high priority buildings. However, due to the high energy intensity and severity of identified issues, Montague should place a **high priority** on funding retrofits for the Carnegie Library.			
Medium Priority			
Millers Falls Library	157	119	65
Key Interpretations: The Millers Falls Library consumes a low amount of energy, yet has a high energy intensity. Although improvements to this building will not have a significant impact on the town's energy consumption, improvements to the envelope will likely improve its efficiency. Montague should consider the Millers Falls Library as a **medium priority** for investment.			
Colle Opera House	198	10	-
Key Interpretations: The Colle Building has a relatively low energy consumption and the lowest *energy use intensity* of the analyzed buildings. Improvements to this building are readily available but will have a smaller impact to the town's overall energy consumption. As such, it should be given a **medium priority** for further assessment – but thoroughly examined for opportunities nonetheless.			
Montague Center Library	197	73	65
Key Interpretations: The Montague Center Library consumes a low amount of energy, and has an average *energy use intensity*. Improvements to the envelope and electrical consumption are readily available and should be given a m**edium priority** for investment.			
Lower Priority			
Montague Senior Center	146	88	65
Key Interpretations: The Montague Senior Center consumes a low amount of energy, and has an average *energy use intensity*. Improvements to this building will not have a significant impact on the town's consumption and energy conservation measures are more difficult to identify. Montague should place a **lower priority** on assessments for the Senior Center.			
Airport	62	82	65
Key Interpretations: The Airport building consumes a low amount of energy, and has an average *energy use intensity*. Heating accounts for 61% of the building's total energy consumption, while electricity accounts for			

49%. As the building has the lowest heating fuel consumption compared to the other buildings, it should be considered a **lower priority**.			
Shea Theater	408	36	-
Key Interpretations: The Shea Theater consumes a high energy consumption compared to medium and low priority buildings, but has the second lowest energy use intensity. Although improvements to this building will have an impact on the town's overall consumption, solutions may not be as readily available. Montague should consider the Shea Theater a l**ower priority** for additional assessments.			

**Weather Normalized* *Blank Cells indicate no data or inadequate data*

4.2 Graphical Representation of Key Building Characteristics

The following section provides additional graphical representation of Montague's energy consumption for the most recent and complete (i.e., data) fiscal year. The top ten buildings are displayed and ordered in terms of annual energy consumption (**Figure 73**) and EUI (**Figure 74**). The top ten electric and primary heating fuel accounts are displayed in **Figure 75** and **Figure 76** respectively.

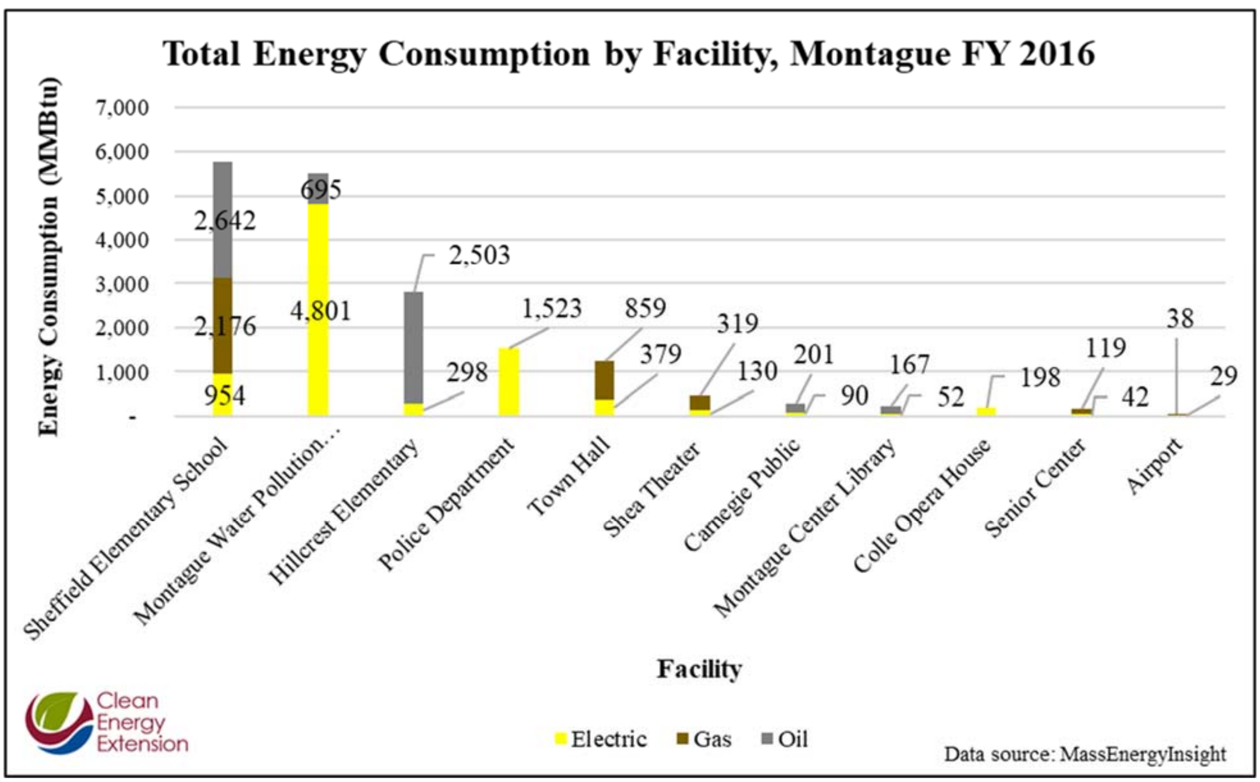


Figure 73. Total energy consumption by facility

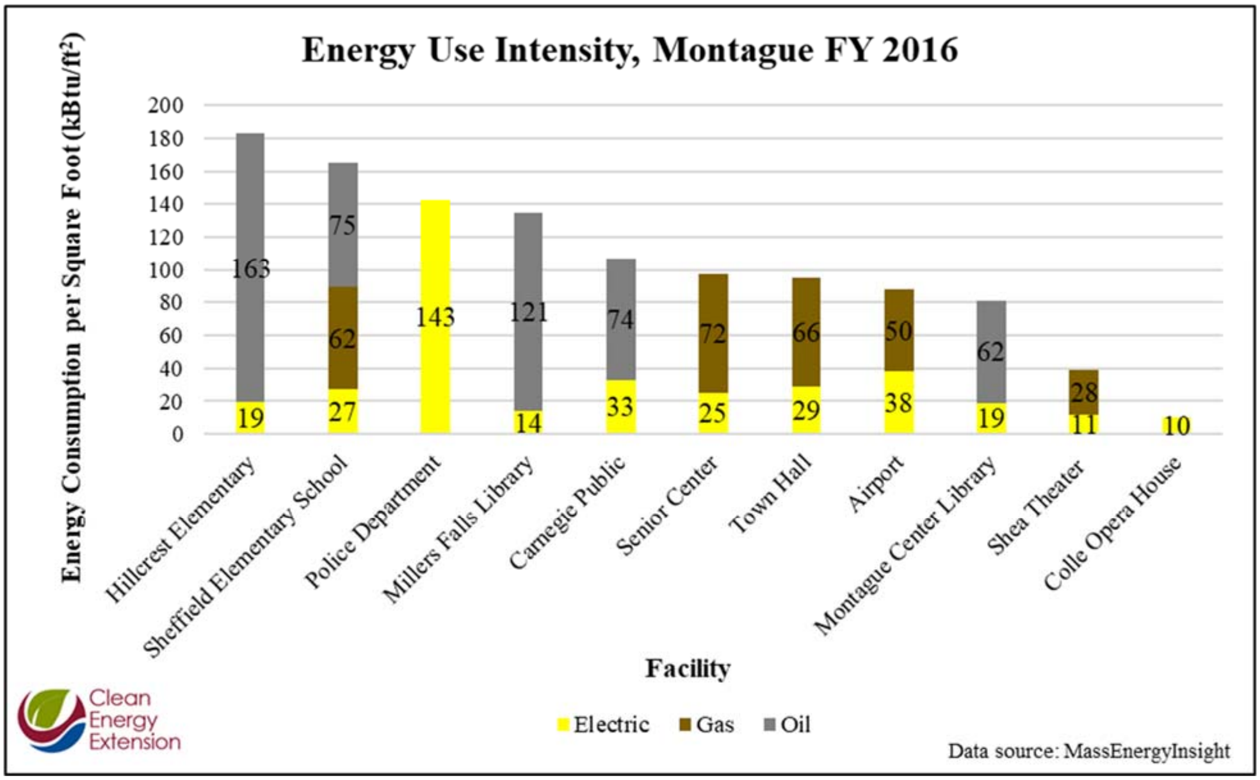


Figure 74. Municipal Energy Use Intensity by facility

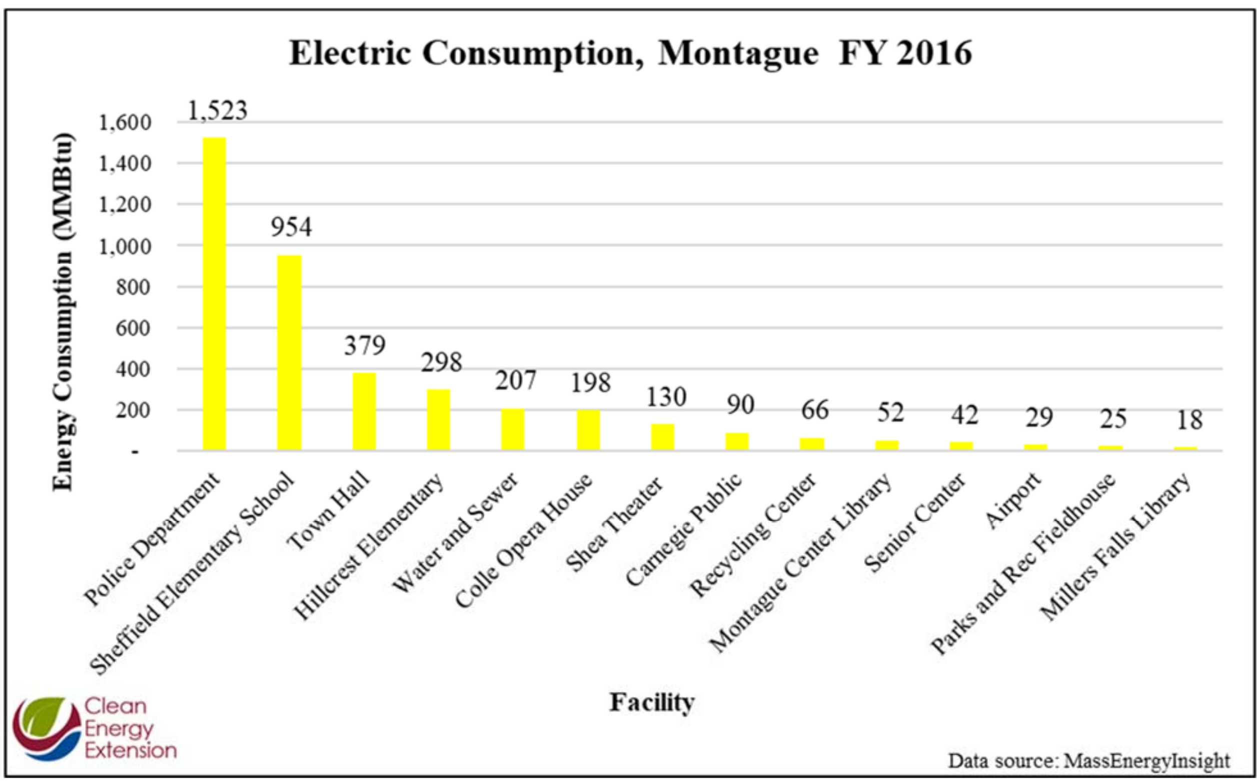


Figure 75. Municipal electric accounts ranked by consumption

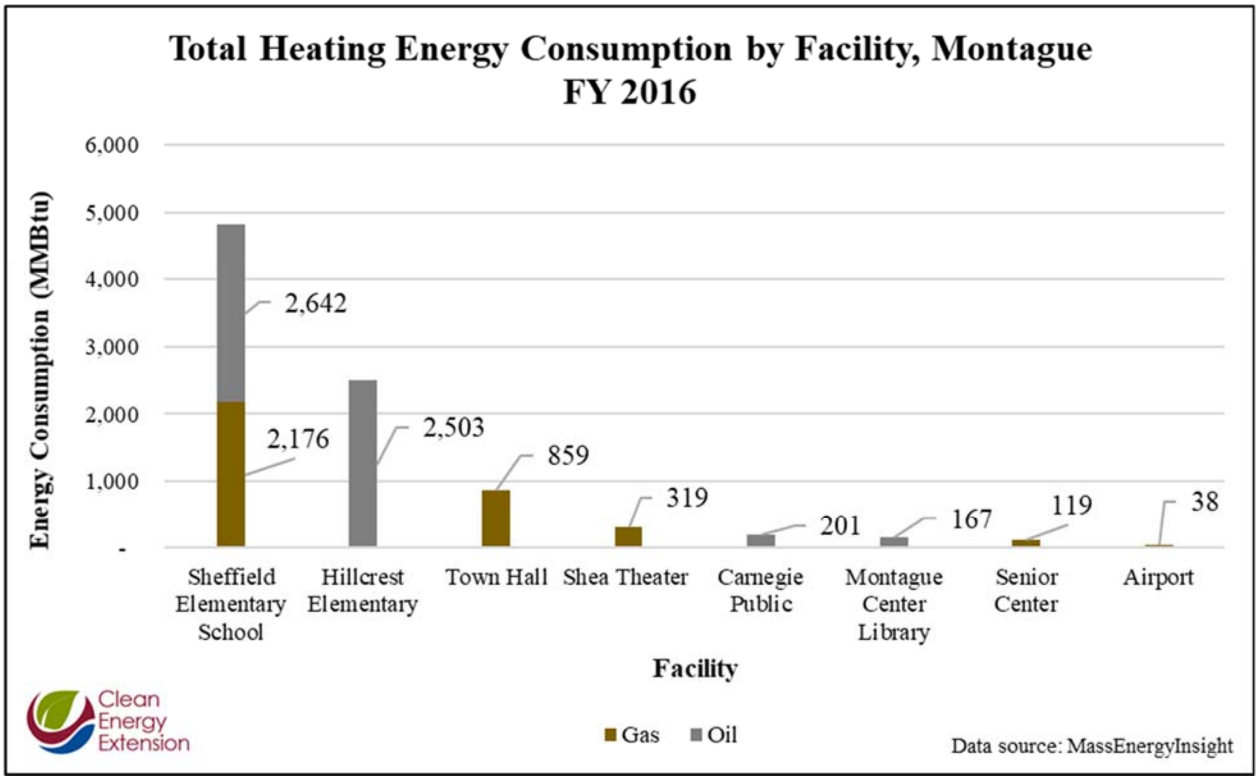


Figure 76. Municipal Heating accounts ranked by consumption

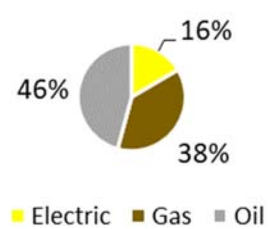
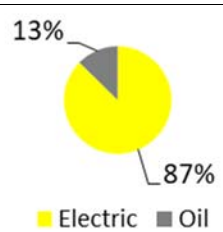
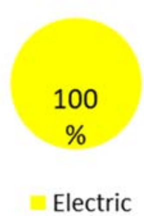
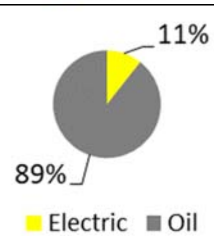
5. Considerations for Energy Project Prioritization & Recommendations

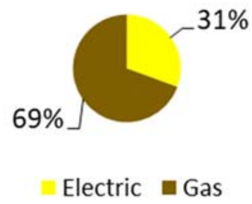
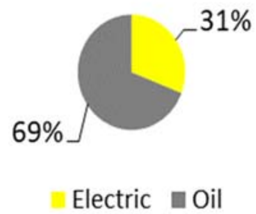
Facility-specific recommendations from CEE's analysis of Montague's energy data and observations from the walk-throughs are addressed and prioritized below. In addition, CEE identifies some organizational suggestions that may help improve inter-departmental awareness of clean energy progress, initiatives, and/or practices.

5.1 Recommended Retrofit Prioritization

As previously introduced in **Table 16**, the buildings included in **Table 17** below are responsible for approximately 80-90% of the total municipal building energy use. To illustrate which retrofits or ECMs would likely provide the largest consumption reduction, recommendations for each facility are classified as either high or low priorities.

Table 17. Recommended prioritization by facility and energy use breakdown

Building Name	Energy Use Breakdown	Retrofit Prioritization
Sheffield Elementary School & Administration Building.		**High Priority Retrofits** – Window replacement (Sheffield Administration Building) – Mechanical room air sealing; weatherization of the doors – Bulkwater management and structural repairs – Add large fan (e.g., "Big Ass Fan" brand) in the center of the auditorium to help de-stratify air – Seal and insulate building exhaust vents **Low Priority Retrofits** – Find alternative uses for the auditorium during non-school hours – Retrofit motion detectors to control heating as well as lighting
Montague Water Pollution Control Facility		**High Priority Retrofits** – Investigate WWTP specific energy efficiency opportunities identified in Appendix A **Low Priority Retrofits** – Replace boiler in Operations Building and upgrade control system
Police Department		**High Priority Retrofits** – Update HVAC controls to manage occupied hours and set points. – Investigate the installation of a ground-mounted PV system **Low Priority Retrofits** – Insulate the roof access hatch
Hillcrest Elementary School		**High Priority Retrofits** – Repair boiler or replace with modern wood heating steam boiler. – Air seal and insulate existing passive ventilation system – Update HVAC controls **Low Priority Retrofits** – Move forward with electrical retrofit recommendations indicated by previous audit introduced above

Town Hall		**High Priority Retrofits** – Air seal and additional insulation the attic – Air seal and insulate envelope gaps in basement **Low Priority Retrofits** – Add variable frequency dives (VFDs) to hot water – Introduce PV system to minimize high electricity costs
Carnegie Library		**High Priority Retrofits** – Conduct air quality assessment – Review ventilation infrastructure – Reduce air 'stack-effect' within the south stairwell – Weather-strip doors – Main entranceway envelope delineation **Low Priority Retrofits** - Add window inserts to help improve efficiency

5.2 Prioritization by Funding Opportunities

CEE recommends that Montague first implement ECMs that will likely receive funding through the applicable sources as discussed in **Section 6.** Once these retrofits and assessments have been addressed, retrofits with the highest potential to reduce municipal energy consumption and operational costs should be prioritized.

5.3 Organizational Recommendations

In addition to the following infrastructure related changes, CEE suggests that Montague creates a digital storage location where information, audits, and best-practices pertaining to Montague's energy projects can be stored and easily accessed (e.g., Drop Box or Google Drive). Finding an online system that meets security needs as determined by the town is an important factor. As indicated through interviews with Montague's staff, individual facility audits and/or projects are not always stored in a manner that can be accessed by municipal officials. Increased transparency and understanding of previous, current, and proposed projects could be helpful in furthering energy efficiency goals and projects, while reducing operational costs.

6. Clean Energy Technologies

Understanding the baseline energy conditions described earlier in this report provides a strong foundation to identify and implement energy improvements. This section provides an overview of energy efficiency opportunities and clean heating and cooling technologies, with more details provided in the appendices. As funding arguably is the most important element of any energy-efficiency project, municipalities have a myriad of potential avenues at their disposal.

This information will help to familiarize the town with potential options to reduce its energy consumption, operating costs, and overall environmental impact. CEE staff is available to discuss these options and how they apply to the town's facilities and operations.

6.1 Efficiency in Building Operations

Opportunities to improve energy efficiency may include equipment upgrades, building envelope improvements, maintenance practices, behavioral or operational changes, or the use of automated controls. The effort and cost required to implement energy efficiency improvements ranges from little or no-cost modifications of existing equipment and/or behaviors to major investment projects.

Cities and towns that have earned Green Communities designation from the Massachusetts Department of Energy Resources (DOER) are eligible for grants to help fund energy efficiency projects. For more information, see http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/. Also consult with your utility company to find out about eligibility for Mass Save incentives or rebates.

See **Appendix A** for information on energy efficiency best practices.

6.2 Clean Heating and Cooling

Clean heating and cooling, or renewable thermal technologies can be used to substantially reduce or eliminate consumption of traditional fossil fuels in municipal buildings. Established technologies include air-source heat pumps, ground-source heat pumps, solar thermal heating, and modern wood heating.

The Massachusetts Clean Energy Center's (MassCEC) Clean Heating and Cooling programs offer rebates to support the installation of renewable heating, hot water, and cooling technologies at facilities across the Commonwealth. These technologies are generally more cost-effective to operate than traditional fossil-fuel systems and can reduce greenhouse gas emissions, while maintaining a high level of comfort, automatic operations, and reliability. MassCEC provides substantial rebates toward implementation of clean heating and cooling systems. Find more information on the programs and technologies at http://www.masscec.com/government-non-profit/clean-heating-and-cooling, as well as in **Appendix B**.

DOER is currently finalizing its Alternative Portfolio Standard (APS) regulations, which will provide additional incentives for the operation of clean heating technologies. Grants received through the Green Communities program may also be applied to clean heating and cooling systems upon review with DOER.

Additionally, if some municipal buildings are clustered together, there may be an opportunity for a district heating system where centralized heating equipment serves multiple buildings, which may reduce the capital and operational costs for new clean heating equipment. Other technologies such as combined heat and power can be used with district heating for increased efficiency and reliability.

See **Appendix B** for additional information on clean heating and cooling technologies.

6.3 Solar Power Generation

Generating electrical power onsite can often provide environmental and financial benefits to a community. Solar electric systems, also known as solar photovoltaics or solar PV, convert sunlight into electrical energy through an array of solar panels that connect to a building's electrical system or directly to the electrical grid.

With federal and state incentives, solar electricity is often a cost-effective way for municipalities to reduce their energy costs for the long run, while also reducing their environmental impact. A robust solar industry in Massachusetts is eager to work with municipalities to develop, host, or serve as net metering off-takers for solar electricity.

Additional information relating to solar photovoltaic systems can be found on the MassCEC website: http://www.masscec.com/solar-electricity. The Department of Energy Resources is launching its new SMART program (http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/rps-aps/development-of-the-next-solar-incentive.html) in 2018 to continue to advance the solar PV market in Massachusetts.

6.4 Vehicle Operations

Vehicle fuel accounts for as much as a quarter of total energy consumption for many Massachusetts municipalities, but it may be overlooked during efficiency assessments. There are several other ways to reduce vehicle fuel use:

- Right-size vehicles for their tasks
- Optimize vehicle routes
- Regularly check and maintain air pressure in tires
- Educate employees on vehicle idling protocols
- Evaluate hybrid, electric or more efficient models vehicles to replace the vehicles that currently use the most fuel
- Consider fuel efficiency and alternative fuel vehicles in all new vehicle purchases, including those that are exempt from Green Communities criterion 4 mandatory efficiency improvement requirement

7. Next Steps

Using municipal building information and historical energy data, our findings and recommendations for Montague are summarized below. These specific buildings have been identified as high priorities for the town based on a combination of overall energy consumption, and opportunities as discussed in **Table 17.** This section seeks to:

(1) Reiterate the specific recommendations that could have the largest impact on municipal consumption reduction and to identify of future audits (**Section 7.1**);

(2) Provide further guidance on audit selection and implementation **(Section 7.2**); and,

(3) Further identify project implementation funding mechanisms and resources not included above (**Section 7.3**).

7.1 Recommendations for Municipal Energy Reduction

As a next step, **Montague may wish to contact CEE to schedule an initial conference call to discuss the findings herein** (413-545-8510, energyextension@umass.edu). This discussion may include a review the municipal energy analysis, target strategies, and support a plan for reducing municipal energy consumption. After the review call, the municipality may wish to schedule energy audits for highest priority municipal facilities identified in this report. When soliciting potential auditors, ensure they are prepared to consider both thermal and electric opportunities.

- **Sheffield Elementary School** – The Sheffield Elementary School has both the highest overall energy consumption and *energy use intensity* (i.e., energy consumption per square foot of conditioned space). The school has the highest heating fuel consumption and the second highest electricity consumption. Heating fuel accounts for 83% of the building's energy consumption. Thermal improvements to this building will have a significant impact on the town. As such, Montague should consider allocating funds for projects such as the replacement of windows, air sealing/weatherization in the mechanical room, exhaust vents, and exterior doors, incorporate de-stratifying fan in the auditorium, bulk water management, and structural repairs.
- **Water Pollution Control Facility** – Montague's Water Pollution Control Facility (WPCF) is a relatively significant energy user and as such, warrants a closer look for energy reduction opportunities. However, because wastewater treatment plants (WWTPs) contain specialized industrial-scale equipment, numerous WWTP-specific assistance programs have been established. It is recommended that Montague contact the resources detailed in the report appendices to identify funding and project opportunities.
- **Hillcrest Elementary School** – The Hillcrest elementary has the second highest level of heating fuel consumption, as well and a relatively high energy intensity. Montague should consider examining opportunities to update building HVAC controls, insulate any ductwork, seal any access hatches, and air seal and insulate the existing passive ventilation system.
- **Police Department** – The Police Department consumes a large amount of both electrical and thermal energy, and the building has the second highest energy intensity of all buildings examined. Montage should further assess building set points, scheduling and operation of the HVAC control system, and consider the installation of a roof-mounted PV system.

- **Town Hall** – The Town Hall is a large energy consumer and has a relatively average energy intensity. Overall, the Town Hall has the third highest electric and heating fuel consumption. Montague should consider further air sealing, and add additional insulation within the attic to improve the envelope once the roof has been replaced.
- **Carnegie Library** – The Carnegie Library has a relatively low energy consumption level and a high energy intensity. Due to its low energy consumption, any improvements to this building will have a lower impact to overall municipal consumption than the other high priority buildings. However, due to the high energy intensity and severity of identified issues, Montague should consider: funding an air quality assessment, review ventilation infrastructure, reduce air 'stack-effect' within the south stairwell, and implement weatherization to support main entranceway envelope delineation.

The following are broad-based findings and recommendations that apply across many of Montague's facilities and vehicles.

- **Building Heating Performance** – Our analysis for the buildings that have complete data shows that the facilities mentioned above have heating systems that fire at relatively moderate outside temperatures, an indication of poor thermal performance. CEE recommend that Montague conduct **thermal energy audits** that investigate building operations, heating controls (e.g., thermostat setbacks), and potential envelope improvements.
- **Transportation** – Transportation fuels account for (21%) of the town's total municipal energy use. Montague should make it a **priority** to investigate strategies including but not limited to: route optimization, introduction of efficient hybrid or electric vehicles, and/or considering transportation efficiency best-practices as described within the report.
- **Recommended Audits** – CEE recommends that Montague purse ASHRAE Level II-III Technical Assessment Energy Audits defined in **Table 18** for the following buildings:

  Carnegie Library – Thermal and Air Quality Assessment
  Town Hall – Envelope and Thermal Energy Audit
  Sheffield Elementary and Administration Building – Envelope and Thermal Energy Audit

7.2 Audit Selection and Audit Implementation

Not all audits or energy assessments are the same. Choosing the right audit level (e.g., ASHRAE Level I, Level II, or Level III) or energy assessment can be challenging due to the various options and entities engaged with these processes. Nearly all assessments will examine lighting (low-hanging fruit[13]), yet those reviewing a building's envelope and insulation are less common. This is particularly common in Massachusetts as municipal buildings with oil and/or program heating systems are ineligible for Mass Save ™ incentives. A municipality may wish to specifically address what systems should be included in any contractual language for an assessment using language such as "including, but not limited to". For unique facilities (e.g. emergency/police/fire or wastewater facilities) municipalities may wish to call out the specific needs of those facilities (e.g., truck bay doors, aeration and mixing).

[13] Energy Conservation Measures with low costs and high energy savings.

To help further illustrate the differences between these audits, please see **Table 18** created by DOER on the following page. There are several important factors that should be directly addressed with the auditor to help ensure the energy assessment is as comprehensive as possible as indicated below:

- Specify the scope[14] and payback criteria[15];
- Require the energy auditor to identify the anticipated amount of all utility incentives for measures with a payback of 10 years or less;
- Suggest that the energy auditor include all measure for all facilities in a single table including: facility, measure, annual cost savings, project cost, utility incentives, net project costs and measure life;
- Be prepared with accurate and complete energy usage and cost data; and,
- Plan for funding and recommended energy conservation measures.

[14] Refers to the buildings systems attributes that will be addressed.

[15] Refers to the measures a client will choose to implement based upon how long it takes to recover (pay back) an initial investment in a cost-saving measure. It is important to specify expectations in any contractual language for an assessment.

Table 18. Energy Assessment Option Review

How to Choose An Energy Assessment for Municipal Buildings in Massachusetts

Auditor	Mass Save	Mass Save	Private Vendor	Private Vendor	Private Vendor	Energy Services Company (ESCO)	Private Vendor
Type of Assessment	**Municipal Program Assessment**	**Technical Assessment**	**Scoping Audit**	**Energy Assessment**	**Technical or Modeling**	**Investment Grade Audit**	**Time-of-Use and/or Streamlined Modeling**
ASHRAE Level	1-2	3	1	2	3	3	N/A
Cost	None	None	Low	Medium	High	High	Low
Purpose	To identify ECMs that are eligible for incentives	To study specific ECMs	To determine whether a building is worth investing time and money for a more thorough audit	To identify ECMs	To model complex building systems or study specific ECMs	To identify ECMs that may be used to fund additional capital measures (roofs, windows, etc.)	To rapidly identify ECMs
Pros	Identify incentives May be implemented directly with vendor	Identify incentives May be implemented directly with vendor	Gives overview of potential ECMs	Will identify incentives if in scope	Costs are bid-quality Will id incentives if in scope	Costs are bid-quality Provides a means to fund ECMs with a range of payback periods and other capital measures	Fastest method to identify ECMs Low and no-cost operational measures identified
Cons	No oil/propane heated measures Limited to measures <7 year payback May require further study	No oil/propane heated measures Limited to measures <7 year payback	Little or no cost and energy savings information Unlikely to identify incentives Lack of coordination with utility	Costs are an estimate May limit measures based upon payback or scope if not specified Lack of coordination with utility	High cost Lack of coordination with utility	If used solely for auditing, very high cost Lengthy procurement and contract process for implementation Lack of coordination with utility	May or may not identify incentives Lack of coordination with utility
Best for Goals	A, D, F	A, D, E, F		A, B, D, maybe F	A, B, D, E, maybe F	A, B, C, D, maybe F	A, G

ECM = Energy Conservation Measure

Goals:

A. Save energy costs through immediate implementation of efficiency projects
B. Identify all efficiency measures to create a comprehensive, long-range energy efficiency plan
C. Assess whether energy efficiency projects could fund other projects needing capital
D. Determine the best project(s) for use of a specific funding source
E. Obtain technical information necessary to move a complex project forward
F. Determine the Mass Save incentives available for efficiency measures
G. Identify operational efficiency opportunities for immediate implementation and energy savings

4/8/14 5

7.3 Project Funding Implementation Mechanisms and Resources

Funding is a critical component of any energy project. Municipalities have a myriad of internal and external funding mechanisms that can be used to help move ECMs forward. This section introduces different types of internal and external funding mechanisms; however, this list is not exhaustive. In addition to the resources below, Montague should contact its utility representatives and follow up with its Green Communities Regional Coordinator for additional resources.

Internal mechanisms

Internally financed projects are paid directly with available cash from either a current operating budget or capital funds. These funding mechanisms allow the municipality to retain all the savings, and avoid complex contract negotiations. Although the simplest and most direct method to pay for improvements, most municipalities have little discretionary funds due to competing operating and capital investment needs. Internal financing should support a portion of the investment portfolio.

Operating Budgets

Smaller projects with high internal rates of return can be scheduled for implementation during the budget years for which they are approved.

Capital Budgets

Large projects can be scheduled for implementation over the full-time period which the capital budget is in place.

Revolving Investment Fund

Creating a revolving investment fund can help capture returns from energy-efficiency investments that can significantly leverage financing for internally funded projects by taking a percentage of acquired savings and reinvesting in other projects. Even with small initial capital resources, revolving funds can grow quickly through reinvestment revenues. The main drawback with revolving funds is the relatively long period of time required to see full savings.

External mechanisms

For a further detailed list, please review The Massachusetts Database of State Incentives for Renewables & Efficiency, operated by the North Carolina Solar Center at NC State University (http://programs.dsireusa.org/system/program?fromSir=0&state=MA); Inquire with your utility provider representatives, and Green Communities Regional Coordinator.

Utility Supported Programs & Incentives

Energy efficiency programs are administered by Mass Save (https://www.masssave.com/en/), an entity contracted by Berkshire Gas, Blackstone Gas Company, Cape Light Compact, Columbia Gas of Massachusetts, Liberty Utilities, National Grid, Eversource, and Unitil. Mass Save is intended to serve as a "one stop shopping" for electric and gas efficiency programs offered by these utilities. The range of rebates and technical assistance through different initiatives is broad. For information on offerings for your area, visit the Mass Save website where you can search for programs by location and project types.

Mass Save

Asides from prescriptive energy-efficiency measures (e.g., high efficiency lighting fixtures or water heaters), custom incentives apply to more complex one-of-a-kind measure that go beyond traditional guidelines. Incentives for custom projects are based on the economics of the project and are typically up to 50 percent of the incremental cost of equipment. An experienced energy engineer will complete a study to assess the savings of high-efficiency designs versus the minimum requirements of the Massachusetts building code. Program administrators may

provide an incentive of up to 50 percent of the total cost of the study (https://www.masssave.com/en/saving/business-rebates/custom-upgrade-projects).
These projects include, but are not limited to:

Lighting systems; HVAC systems; Demand Control Ventilation; Solar Thermal Systems; Energy Management Systems; Compressed Air Systems; Heat Recovery; Pumping Systems; and, Combined Heat and Power (CHP).

Gas Networks Consortium

Customers of Berkshire Gas, Blackstone Gas Company, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil can receive incentives through the Gas Networks consortium. Gas Networks sponsors rebate programs for high efficiency natural gas furnaces, boilers, water heaters, infrared heating, and commercial food service equipment.
http://www.gasnetworks.com/energy-efficiency-programs/commercial-rebates/

ISO New England

The Independent System Operator New England Inc. (ISO-NE) offers its Demand Resources programs, which provide payments to electricity users for load reductions (of as little as 100 kW), either by reducing usage or operating on-site generation during periods of high demand. Customers may participate in the programs through any participating member ("Market Participant") of the New England Power Pool, such as a utility company, power marketer, competitive energy supplier, or independent curtailment service provider (https://www.iso-ne.com/markets-operations/markets/demand-resources).

8. Acknowledgements

CEE is grateful to all of Montague's staff and town officials for their support and contribution to the development of this report. CEE would especially like to thank the following individuals for their support during this project:

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Chip Dodge (Chief of Police)

Roberta Potter (Director, Council of Aging)

Jim Whiteman (Department of Public Works)

Linda Hickman (Director, Montague Public Libraries)

Bryan Camden (Airport Manager)

Montague Energy Committee:

Chris Mason (Committee Chair)

Gill-Montague Regional School District:

Jim Huber (Facilities & Energy Manager)

Appendix A – Municipal Energy Efficiency Best Practices

The UMass Clean Energy Extension recommends that municipalities consider the following energy efficiency best practices. Financial support for these efforts may be available through Green Communities grants or Mass Save incentives or rebates. For more information, see http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/ and consult your utility company representative.

Optimize Building Controls

Many buildings have building/energy management systems or programmable thermostats that are not operating to their full potential. These control systems need to be properly programmed and maintained in order to be effective in optimizing building operation and energy use. Energy efficiency opportunities may be identified by periodically retrocommissioning these systems or reviewing temperature setpoints and schedules, comparing to building occupancy, making any necessary adjustments, and testing to make sure that the related equipment is operating as intended.

Control systems may record environmental conditions and operational parameters, and review of this data can be very helpful in maximizing the value of the system and identifying any performance problems with HVAC equipment.

For selected buildings, utility companies may be able to provide electrical billing data in 15-minute intervals, which can also be very useful in understanding electricity use patterns throughout the day/week and identifying opportunities to optimize building operation.

Several Green Communities have seen great benefits from these practices, some with the assistance of fault detection and diagnostic software or circuit-level monitoring by consulting companies. Utility pay-for-performance programs may provide incentives based on the achieved savings.

Install/Upgrade HVAC controls

Advanced controls can improve the efficiency of some HVAC systems without the substantial investments required to replace major equipment. These technologies include:

- Energy recovery ventilators or heat recovery ventilators use a heat exchanger to preheat or precool incoming fresh air by reclaiming energy from the outgoing exhaust air.
- Demand control ventilation automatically adjusts the amount of outside air let into the building to optimize energy use while providing occupants with the right amount of fresh air.

Integrate Energy Efficiency into Purchasing Decisions

Efficiency ranges widely for many types of energy-consuming equipment. Incremental costs range depending on the product type, but sometimes there is sometimes little to no added cost for high efficiency models of new equipment, and in other cases the long term energy savings can justify a higher purchase price for an efficient model. Information about efficiency of many types of products – including appliances, commercial kitchen equipment, electronics, HVAC equipment, office equipment and more – is available from the ENERGY STAR program at http://energystar.gov/products and http://energystar.gov/purchasing.

Use Power Management Software on Computers

The ENERGY STAR program offers free support on computer power management to reduce electricity consumption when computers are not in use, detailed at http://energystar.gov/powermanagement.

Implement an Energy Engagement Program

Some Green Communities have had success with programs that educate municipal employees, students and other building occupants about their energy reduction goals and encourage simple behavioral actions such as turning off lights, computers and other equipment when not in use.

Investigate Energy Efficiency Opportunities in Water and Wastewater Treatment Plants

Water and wastewater treatment plants are often among the highest energy consuming facilities in cities and towns. Support for projects in these facilities may include the following programs, where applicable:

- The **UMass Center for Energy Efficiency and Renewable Energy**, CEE's partner organization, offers free, in-depth assessments of plants with annual energy costs of at least $100,000. The Center conducts a site visit with a thorough review of equipment and processes, then provides a detailed report with recommended energy efficiency opportunities, including estimates for energy and cost savings and implementation costs. More information is available at http://ceere.org/iac.
- The **Massachusetts Department of Environmental Protection** (MassDEP), with funding assistance from the Massachusetts Department of Energy Resources, is planning to award grants to municipal water and wastewater treatment plants in support of clean energy and increased efficiency in our water infrastructure. The agency is planning to make grant applications available in the fall of 2017. For more information, see http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/ or contact MassDEP: Michael DiBara, (508-767-2885, michael.dibara@state.ma.us), James Doucett (617-292-5868, James.Doucett@state.ma.us), or Ann Lowery (617-292-5846, ann.lowery@state.ma.us).
- **MassCEC** is offering up to $150,000 in funding for the piloting of innovative technologies at publicly-owned wastewater treatment facilities across the Commonwealth. This program focuses on innovative technologies aimed at one the three focus areas: (1) increasing energy efficiency, (2) recovering resources for reuse, or (3) removing nutrients including nitrogen and phosphorous. Additional information can be found on the MassCEC website: http://www.masscec.com/innovation-wastewater-treatment-plants.
- **Mass Rural Water Association** (MassRWA) provides free on-site technical assistance to small and rural wastewater treatment and collection systems through the Wastewater Technical Assistance Program and the Wastewater Training and Technical Assistance Program both funded by the U.S. Department of Agriculture's Rural Utilities Service. These programs provide hands-on assistance and training to wastewater systems in areas such as operator certification, treatment, biological process control, laboratory procedures, collection systems, smoke testing, and maintenance. The emphasis of the technical assistance is promoting low cost, long-term solutions. Learn more at http://massrwa.org/ or contact Dave Kaczenski (dkaczenski@massrwa.org) for assistance or information about MassRWA's Wastewater Programs.
- The **Water Innovation Network for Sustainable Small Systems** (WINSSS) at UMass develops research opportunities, conducts piloting projects, and provides technical assistance at small-scale wastewater and drinking water systems. Learn more at http://www.umass.edu/winsss/ or contact Patrick Wittbold (pwittbold@gmail.com) for more information.

Appendix B – Clean Heating Technologies

Clean heating and cooling, or renewable thermal, technologies can be used to substantially reduce or eliminate consumption of traditional fossil fuels in municipal buildings. The following are descriptions of these technologies from the Massachusetts Clean Energy Center website. See more information at http://www.masscec.com/government-non-profit/clean-heating-and-cooling.

Air-Source Heat Pumps

Air-source heat pumps (ASHPs) can provide cost-effective and energy-efficient heating and cooling for your building's space. While traditional systems burn fuel to create heat, a heat pump instead works by moving heat into or out of a space. Though they require electricity to operate, efficient ASHPs use 40-70 percent less electricity than traditional electric-resistance heating. Rebates of up to $210,000 are available.

Key points:

- Easy to install in existing buildings and compatible with any type of existing heating system
- Often installed to supplement existing heating systems
- Provide both heating and cooling in a single, efficient unit without the need to install ductwork
- Lowest up-front cost of any clean heating and cooling technology, and can be more cost effective to operate than traditional oil, propane, or electric heat

Modern Wood Heating

Modern wood heating systems use wood chips or wood pellets to produce heat, much in the same way traditional boilers or furnaces use oil, propane, or natural gas. Biomass heating systems can often integrate into existing heating systems, and can fulfill all of a building's heating and hot water needs. Systems are typically fully-automated, and require limited maintenance. Wood chip and pellet delivery is available in most parts of the Commonwealth. Rebates of up to $250,000 are available for commercial-scale systems and $27,000 for small-scale systems.

Key points:

- Typically installed in buildings with baseboard hot water heating, but furnace options are also available for buildings with forced air heating
- Can be more cost-effective than heating with traditional oil, propane, or electric heat

Ground-Source Heat Pumps

Ground-source heat pumps (GSHPs) can provide cost-effective, energy-efficient space heating and cooling, hot water and process heat by utilizing the nearly constant temperature underground to transfer heat between the ground and your facility. GSHPs are typically the most efficient type of heat pump. Though they require electricity to operate, efficient GSHPs can provide the same amount of heating for substantially less than traditional electric heating. Grants of up to $250,000 are available for commercial-scale systems and $25,000 for small-scale systems.

Key points:

- Great option for new construction, but can also replace existing forced air or hydronic heating systems

- High installation costs are offset by long-term energy cost savings compared with electric heat, oil, propane, or even natural gas heating plus highly efficient cooling

Solar Hot Water

Solar hot water systems use the energy of the sun to heat water for use in your home's hot water system. Solar hot water systems reduce the usage of traditional water heating fuels (such as oil, electricity or natural gas) and thereby reduce the amount you spend purchasing these fuels. Rebates of up to $100,000 are available.

Key points:

- Great option for both existing buildings and new construction
- Can reduce water heating costs and greenhouse gas emissions at your facility
- Especially cost-effective for buildings currently heating water with oil, propane or electricity

Appendix C – Extended Building Analysis

Thermal Performance Analysis

Historical energy consumption is compared to historical weather conditions to determine the relationship between energy consumption and weather. From this comparison, the balance point can be calculated. The balance point is the outdoor temperature at which internal systems turn on to heat the building. For internally dominated buildings (e.g., office buildings) a typical balance point is 50°F. For envelope dominated buildings (e.g., traditional house) the typical balance point is 60°F. A building with a balance point that is higher than 60°F is a good candidate for lifestyle or structural changes that would decrease the buildings heat loss through the envelope. This analysis is useful to quickly identify buildings that would benefit from retrofits that could reduce the buildings energy usage per Heating Degree Day (e.g., increased insulation, improved air barrier).

The regression analysis, utilizing fuel delivery data from MEI for the buildings along with local temperature data, are shown on the following pages.

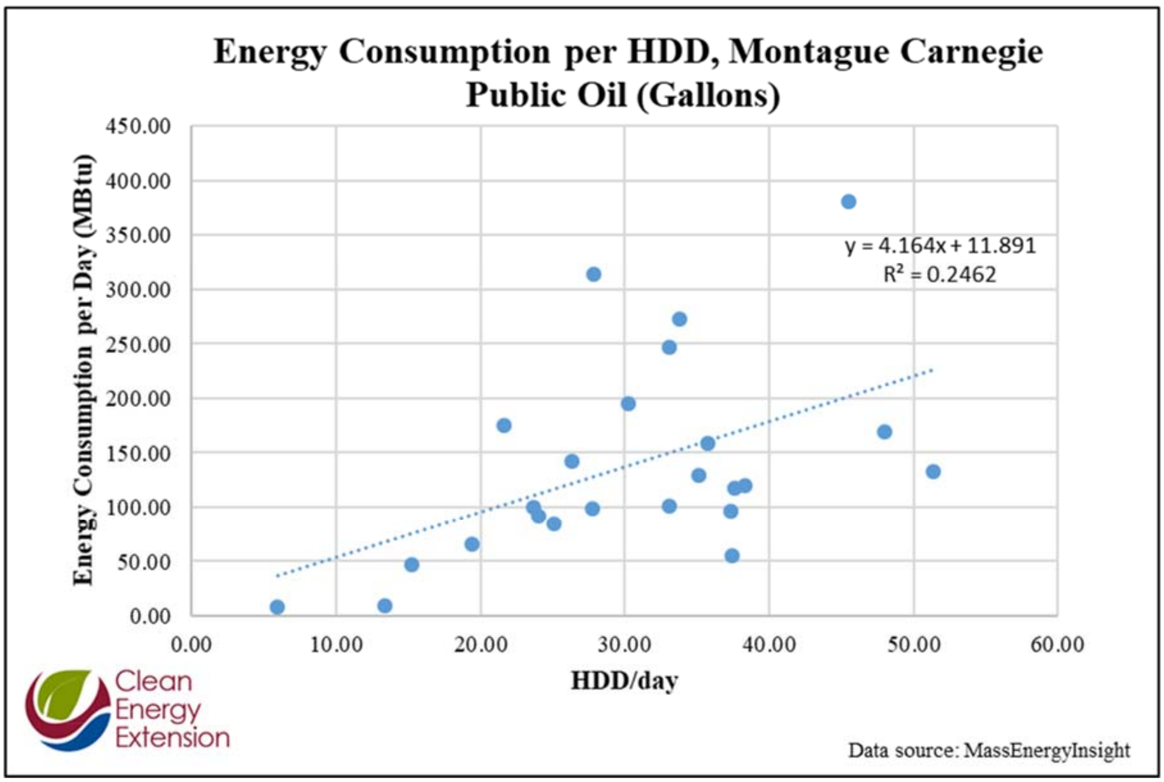

Figure C.1: Regression plot of total energy consumption per heating degree day.

Table C.1: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Carnegie Library Oil (Gallons)	
Intercept	**15th Percentile**
11.89	4.32
Correlation	
R^2	**Pearson**
0.246	0.496
Slope (energy unit/°F)/intercept (energy unit)	4.16
Balance Point (°F)	65.35
Heating Sizing (MBtuh)	4,706.00

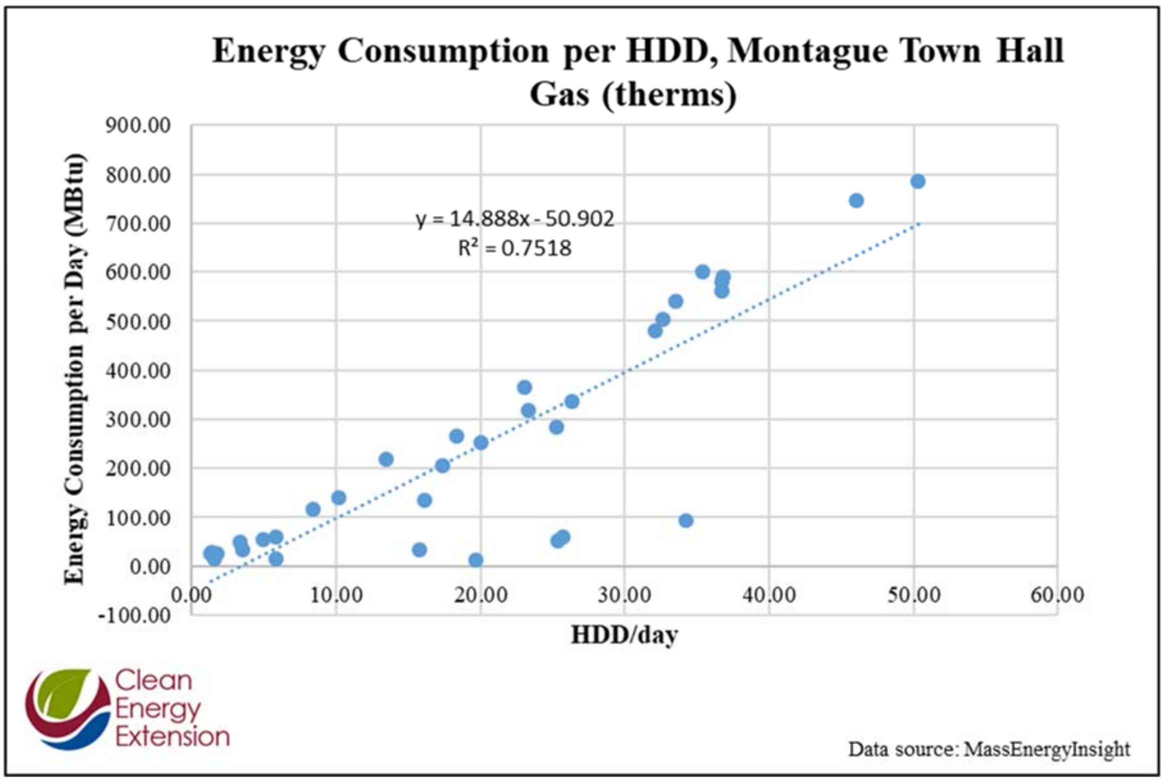

Figure C.2: Regression plot of total energy consumption per heating degree day.

Table C.2: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Town Hall Gas (therms)	
Intercept	**15th Percentile**
-50.90	2.70
Correlation	
R^2	**Pearson**
0.752	0.867
Slope (energy unit/°F)/intercept (energy unit)	14.89
Balance Point (°F)	64.71
Heating Sizing (MBtuh)	12,145.86

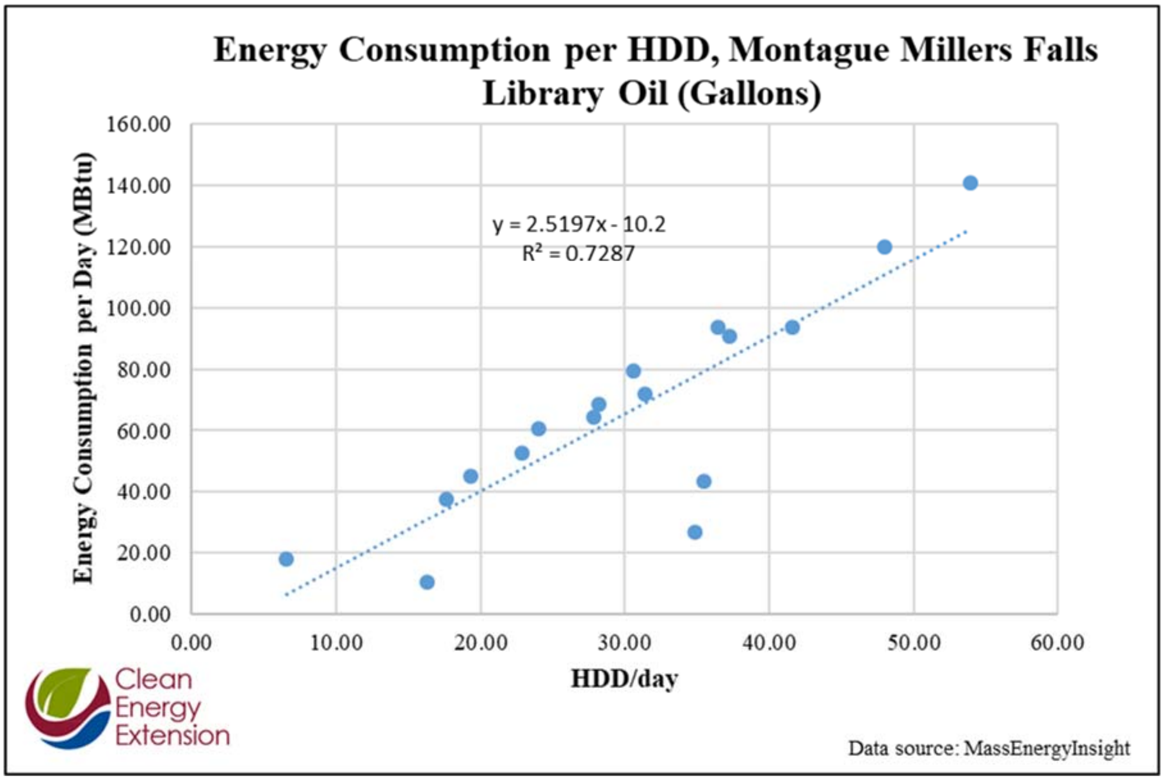

Figure C.3: Regression plot of total energy consumption per heating degree day.

Table C.3: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Millers Falls Library Oil (Gallons)	
Intercept	**15th Percentile**
-10.20	2.24
Correlation	
R^2	**Pearson**
0.729	0.854
Slope (energy unit/°F)/intercept (energy unit)	2.52
Balance Point (°F)	64.75
Heating Sizing (MBtuh)	2,847.62

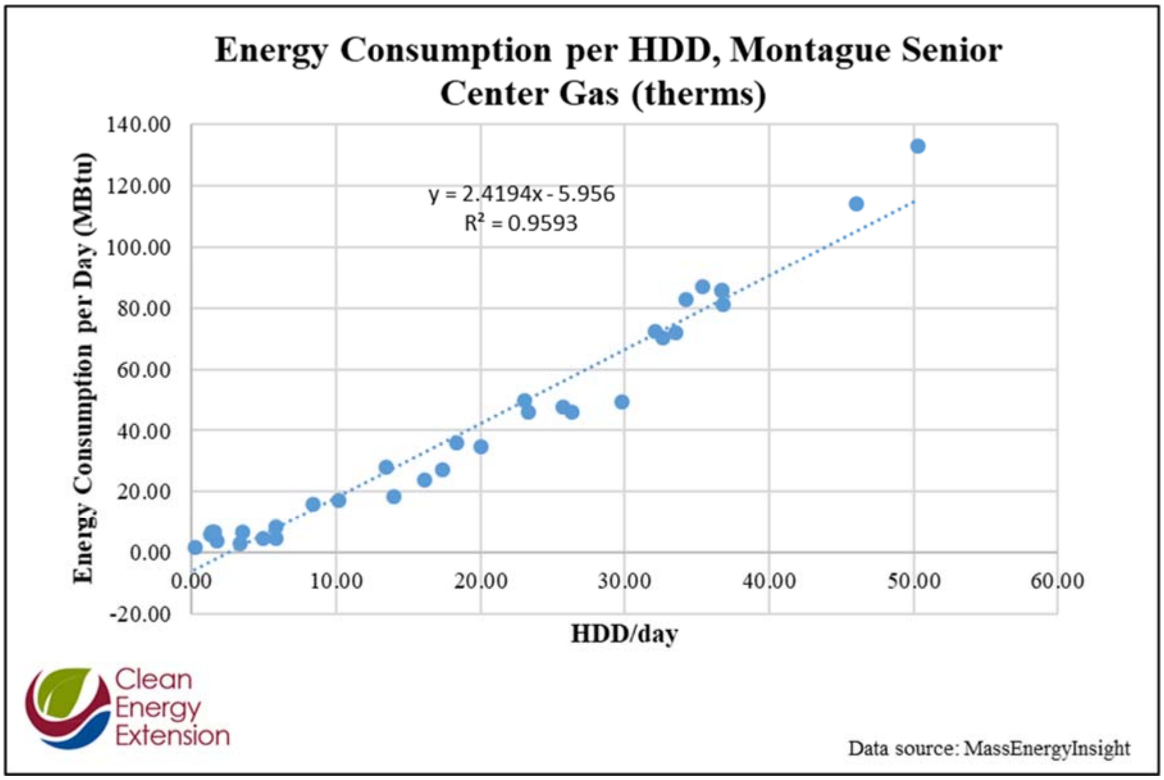

Figure C.4: Regression plot of total energy consumption per heating degree day.

Table C.4: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Senior Center Gas (therms)	
Intercept	**15th Percentile**
-5.96	0.57
Correlation	
R^2	**Pearson**
0.959	0.979
Slope (energy unit/°F)/intercept (energy unit)	2.42
Balance Point (°F)	64.59
Heating Sizing (MBtuh)	1,973.79

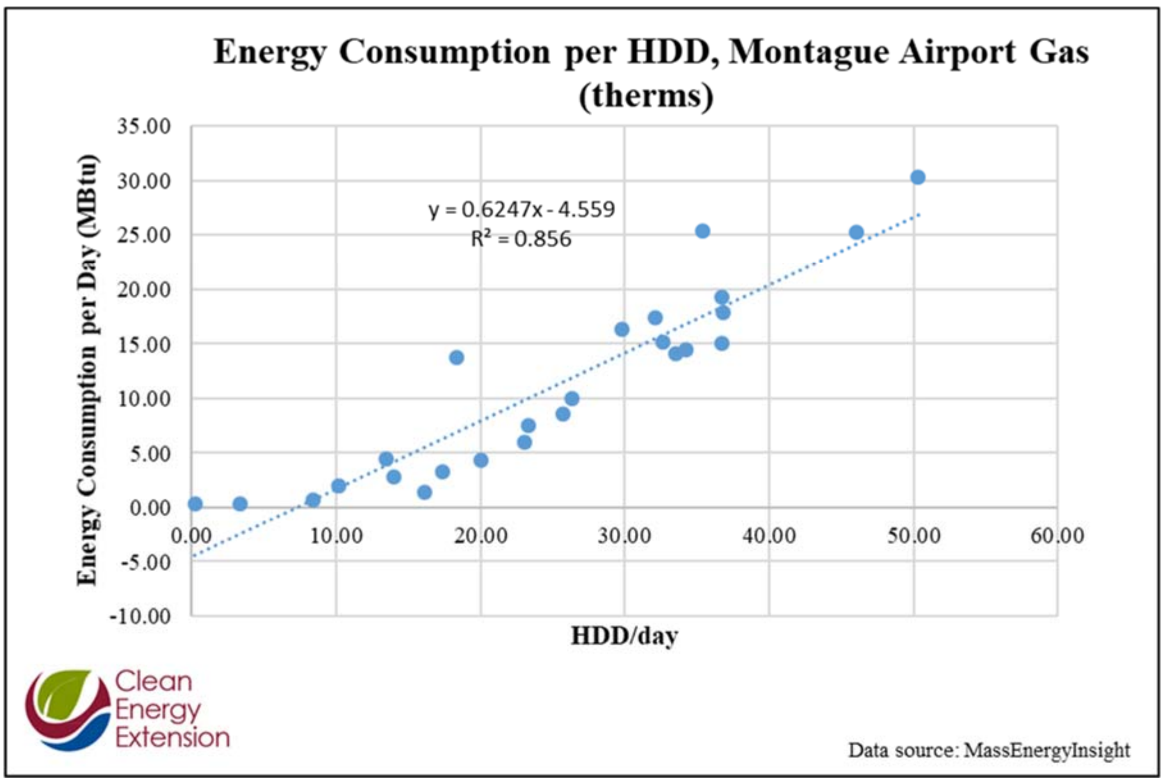

Figure C.5: Regression plot of total energy consumption per heating degree day.

Table C.5: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Airport Gas (therms)	
Intercept	**15th Percentile**
-4.56	0.18
Correlation	
R^2	**Pearson**
0.856	0.925
Slope (energy unit/°F)/intercept (energy unit)	0.62
Balance Point (°F)	64.86
Heating Sizing (MBtuh)	509.62

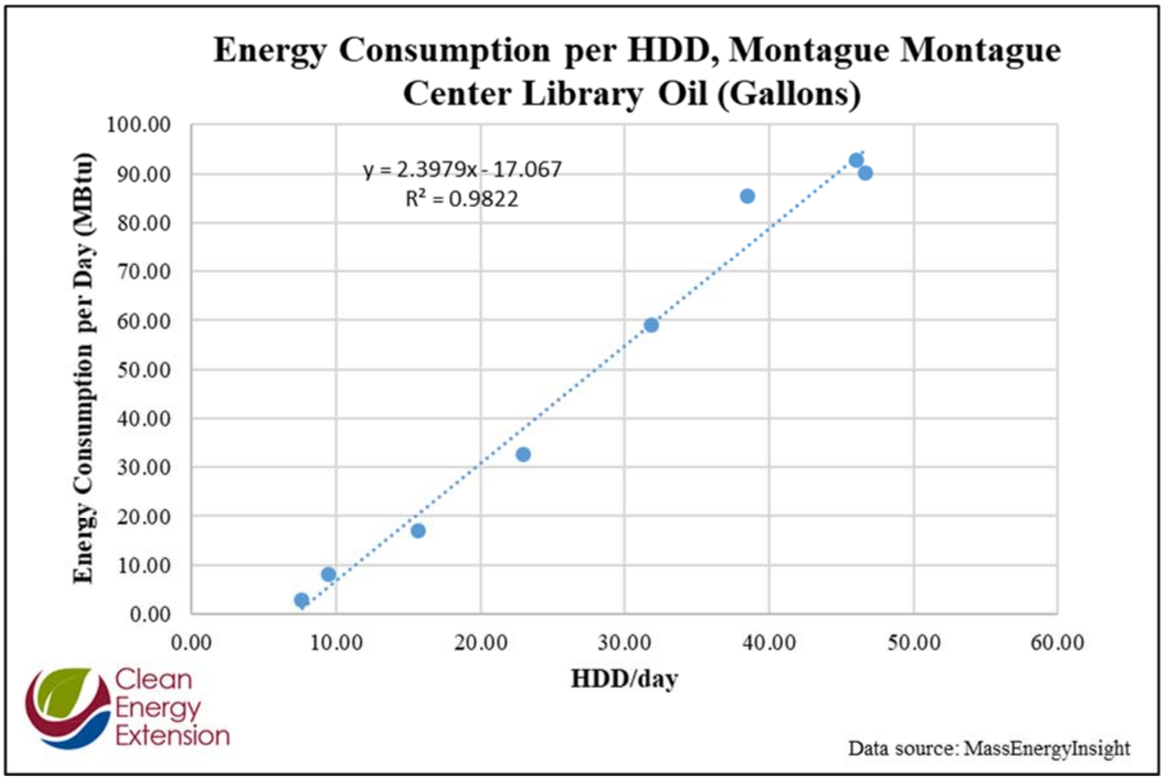

Figure C.6: Regression plot of total energy consumption per heating degree day.

Table C.6: The baseload, balance point, correlation and heating sizing of the building is calculated and displayed in the table below.

Baseload, Montague Center Library Oil (Gallons)	
Intercept	**15th Percentile**
-17.07	0.62
Correlation	
R^2	**Pearson**
0.982	0.991
Slope (energy unit/°F)/intercept (energy unit)	2.40
Balance Point (°F)	64.86
Heating Sizing (MBtuh)	2,710.04