BALES ENERGY ASSOCIATES

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ENERGY STUDY
For the
Petersham Town Office Building

Energy Analysis of Measures
Through the
Massachusetts Clean Energy Center
Green Communities Program

Completed By:

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Introduction

Bales Energy Associates, an energy efficiency engineering firm, was contracted to provide an energy study for selected Town-owned buildings in Petersham, Massachusetts. The study was funded through grant funds provided by Green Communities Program of the Massachusetts Clean Energy Center. The building evaluated in this report is the Town Office Building.

Bart Bales, PE, MSME, senior engineer at Bales Energy Associates, visited the site, reviewed energy usage & billing information, examined relevant equipment and systems, and developed energy analyses and recommendations with regard to each building's energy related systems.

Given the nature of the funding process for the Green Communities Program, a preliminary site visit identified specific measures for inclusion in the current report. Other potential measures indentified in the course of this study have been noted and may be considered for evaluation for future Green Communities grant applications.

The office building's function is to serve as an office space for town personnel and as a meeting space for various town boards. The building is located adjacent to the Town Hall and is a two-story brick structure with and unfinished basement that holds the mechanical equipment, and a walk-up attic that is used for document storage.

Executive Summary

Energy Conservation Opportunities Evaluated

During the proposal and contracting process, specific energy conservation measures needing evaluation were identified at each facility. ASHRAE Level 2 calculations were completed for all measures evaluated.

Enclosure system improvements were the focus of the study at the Petersham Town Office Building.

Key conclusions are the following:

1. **Enclosure Improvements** can substantially reduce the building's heat loss characteristics. Recommendations include:
   - **Remove attic floor boards.**
   - **Air seal bypasses and penetrations between the building's walls and conditioned spaces and the attic**.
   - **Eliminate stair access to the attic and install insulated attic hatch to allow access to attic space.**
   - **Increase insulation in the attic to achieve an insulation R-value of 60.**

The costs, savings, and economic payback for these energy conservation measures are presented in the following Executive Summary Chart. The values shown in the Executive Summary Chart represent the savings with measures taken in the order of economic feasibility shown. The calculations supporting each measure are included in the appendices.

Executive Summary Chart

ECM #	Energy Conservation Measures	Cost	Available Utility Rebates ($)	Total Cost after Rebate ($)	$1.95 $/Gallon Propane Savings (gallons/yr)	Annual Savings ($/yr)	Total Payback (yrs)	Total Payback Payback after Rebates (yrs)	Life Years
1	Attic Insulation & Air Sealing	$4,972	$0	$4,972	225	$439	11.3	11.3	20
	Totals for All Measures	$4,972	$0	$4,972	225	$439	11.3	11.3	

Existing Conditions

Facility Description

The Petersham Town Office Building is brick and mortar structure that comprises two stories, an un-finished basement, and a walk-up attic. It is a low-occupancy building used as office space for town officers, personnel and the several boards and committees necessary to govern the town.

Utility Energy Use

Utility data for a multi-year period was collected. Data for the reference year used, June 2012 - July 2013, is tabulated and reported in the appendices.

Building Enclosure

Exterior walls are constructed of brick as the main structure and an interior layer of plaster and lathe applied directly to the brick with no insulation barrier at any point. The elevation at back of the building is lower than the front. An elevated rear door on the back of the building has been removed and covered over with plywood. Bales Energy Associates recommends that the Town assure that the space behind the plywood has been properly insulated to minimize heat losses through that section of wall.

The windows are wood-framed type with single-pane glazing. Double hung windows are equipped with storm windows. Specialty glazing above some doors is single-pane.

The building has a low-sloped roof with an attic. The attic floor is insulated with 6" of fiberglass insulation. An open set of stairs lead directly to the attic. There is a solid wooden door at the foot of the stairs. The ceiling of the second floor is lower on the side of the attic adjacent to the stairs. These lower ceiling areas are insulated with 2" of rock wool insulation. The interior walls of the higher ceilinged section are not insulated; this represents a thermal bypass in the thermal control layer of the conditioned space.

Bales Energy Associates recommends improving the thermal control layer which separates the second floor conditioned space from the attic.

ECM#1: ATTIC INSULATION & AIR SEALING

Bales Energy Associates recommends the following to achieve a more continuous thermal control layer between the second floor and the attic.

- **Remove all items from the attic. Remove attic floor boards.**
- **Air seal bypasses and penetrations in both attic levels of the second floor ceiling and the common interior wall that joins the higher section of the attic to the lower section.**
- **Insulate both attic floor levels with cellulose to achieve an R60 level for the insulation.**
- **Insulate the common interior wall that joins the higher section of the attic to the lower section wall. Insulate this wall with 4" of (R7) foam insulation for a total value of R28 for the insulation.**
- **Close off the top of the stairs at the level of the lower roof with an insulated panel to complete the thermal control layer at the level of the lower ceiling. Insulate this panel to the same R60 level as the rest of the attic floor. Leave room for attic hatch at top of stairs at the level of the lower ceiling to allow access to attic space**
- **Install a hinged insulated attic hatch at the top of the stairs. Insulate hatch with 4" of (R7) foam insulation.**
- **Insulate the common interior wall of the stairwell with 4" of (R7) foam insulation for a total value of R28 for the insulation. If feasible, below the lower ceiling area, insulate the sloped area beneath the stairs.**
- **Construct wooden barriers around the attic hatch to keep loose blown insulation from entering hatch and stairwell.**
- This measure assumes the eliminating of the attic as an area for storage. (If the Town wished to retain a portion of the attic for unheated storage, a section of the attic could be configured by constructing an elevated deck above the insulation while retaining continuity and thermal performance of the recommended insulation beneath.)

ECM #1	Summary of Energy Savings					
	Baseline Heat Load	After ECM #1	Savings 10E6 Btu/yr	% Reduction		
Building Loss Load (MMBtu/yr)	-201.9	-181.20	-20.69	10.2%		
Existing Boiler Efficiency	84%	84%				
Fuel Energy Usage (MMBtu/yr)	-240	-216				
Energy Savings	% Reduction	Propane Use	Gallons Saved	$/Unit	$ Saved	
	10.2%	2,198	225	$1.95	$439	
				Total Savings ($)	$439	

Attic Insulation & Air Sealing	Cost	Measure	Cost $	Savings $	Payback Years
	$4,972	ECM #1	$4,972	$439	11.3

Note:
Cost estimates were developed by BEA based upon estimates provided by Energia, LLC of Holyoke, MA; Tom Rossmassler, 413-322-3111, ext 20

Heating, Ventilation & Air Conditioning Systems

Boiler

This facility is served by a relatively new propane-fired boiler. The unit is a Buderus boiler (Logano GA124) a rated combustion efficiency of 85% serving a single zone hydronic system.

The design heat load for the building is approximately 93,000 Btu/hr.

Heating Distribution System

The heating distribution system consists of hydronic piping carrying boiler water through 'european' style wall panel, radiative convectors.

Cooling System

The building's occupants currently use portable window air conditioners as needed for cooling.

Operational Guidelines for the Existing Boiler

- Clean and adjust boiler and burner annually. Use electronic test equipment to determine proper air-fuel mixture and proper flame characteristics. Manual, sight-based adjustments do not typically result in optimal system performance. Test for stack temperature, CO2, oxygen, excess air and smoke to optimally tune the burner. Post combustion test results at the boiler and retain copy in electronic records, as well as paper format.

- Program circulation pumps to operate whenever outside air temperatures are 34 F or below.

- Set reduced circulation water temperatures for unoccupied periods to improve night temperature setback by reducing hydronic piping stand-by losses.

Utilize hydronic system's programming capabilities to control temperatures and allow for automatic setback of unused areas during unoccupied hours.

Temperature Control System

The existing temperature controls are adjustable, thermostatic radiator valves installed on individual panel radiators. Manual adjustment of these valves opens and closes the piping orifice allowing variable fluid flow through the unit and thus more/less potential energy available to the space. This method provides reasonable space heating temperature control.

Lighting

The lighting in the building is provided by T-8 fluorescent fixtures. Lighting is not part of the scope of this report.

APPENDICES

UTILITY INFORMATION

Billed Energy Use for Electricity & Fuel					
Jul 2012 - Jun 2013					
Building Name	**Office Building**				
Owner	**Petersham, MA**				
Account #					
	Electricity	Electricity	Propane	Propane	**Energy $**
Month	KWH	Total $	Gallons	$	**Totals**
Jul	779	$111			**$111**
Aug	1,026	$143			**$143**
Sept	858	$121			**$121**
Oct	687	$99	349.0	$680	**$779**
Nov	680	$98			**$98**
Dec	833	$117	679.0	$1,322	**$1,439**
Jan	875	$123			**$123**
Feb	806	$112	656.0	$1,277	**$1,389**
Mar	727	$91	514.0	$1,001	**$1,092**
Apr	760	$111			**$111**
May	730	$107			**$107**
Jun (prev June data)	***711***	***$102***			**$102**
Annual (Units)	9,472	$1,335	2,198.0	$4,280	**$5,615**
Heating Season (Units)	5,368	$752	2,198.0	$4,280	**$5,032**
Annual ($/Unit)		$0.141		$1.947	
Heating Season ($/Unit)		$0.140		$1.947	
	Electricity MBtu		**Propane MBtu**	**Energy Use Totals (Mbtu)**	
Annual (Mbtu)	32,318		209,909.0	242,227	**Energy $ Totals**
Heating Season (Mbtu)	18,316		209,909.0	228,225	
				Totals (Mbtu/sf)	**($/sf)**
Annual (Mbtu/sf)	10.6		68.8	**79.4**	**$1.84**
Heating Season (Mbtu/sf)	6.0		68.8	**74.8**	**$1.65**
Building Name	**Office Building**		**Heated Square Footage**		**3,049**

BOILER SYSTEM INFORMATION

Logano GA124

Sealed combustion and draft induced venting design is perfect for single or multi-family homes and has an efficiency ratings of 85%+

Buderus GA124 boilers are designed for single or multiple famliy homes and guarantee reliable heating for many years. Its construction consists of flexible GL-180M cast iron, designed to resist thermal shock for long life and a high silicone cast iron surface for excellent corrosion resistance.

Advantages at a Glance

- EnergyStar certified
- Sealed combustion and draft induced venting design
- Perfect for single or multi-family homes
- Efficiency ratings of 85%+

Technology

Clean combustion, extremely high efficiency, economical operation, and longevity.

Buderus boilers are the perfect central heating source for single or multiple family homes and guarantee reliable heating for many years.

The modern design of Buderus boilers results from centuries of experience, using the latest combustion and manufacturing technologies.

Whisper quiet operation with integrated draft inducer.

Attractive design with front accessible controls, all piping connections in the rear for finished appearance.

Here, you'll locate hot water tanks, control units or accessories that you can combine to create an optimum system, thanks to the Buderus system design.

Recommended Storage Tanks
Buderus offers a full range of high efficiency indirect water tanks to compliment your boiler.

Controls
Comes standard with the Aquasmart Control

HEAT BALANCE:
BASELINE YEAR

HEAT BALANCE			
GAINS AND LOSSES	**BTU/HEATING SEASON*1E6**		
CONDUCTION LOSSES		-174.0	**Total**
INFILTRATION LOSSES		-27.9	**Losses**
VENTILATION LOSSES		0.0	**201.9**
SOLAR GAIN		28.8	**Total**
OCCUPANT GAIN		1.5	**Gains**
ELECTRICAL GAIN		17.4	**47.7**
NET HEATING DEMAND		-154.2	

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
154.2	209.9	73%

CONDUCTION LOSSES							
#	**Zone**	**UA**	**HOURS/ DAY**	**DAYS/ -**	**TEMP DIFF**	**LOSSES (* 1E6)**	**Sub Totals**
1	**First Floor**	673	8	151	35	28	
		673	16	151	30	49	
		673	24	61	25	25	101.9
2	**Second Floor**	476	8	151	35	20	
		476	16	151	30	35	
		476	24	61	25	17	72.1
	Total UA	**1,149**		**Conduction Total**			**174.0**

INFILTRATION LOSSES

0.4

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	First Floor	13,721	0.40	16	151	0.018	30	7.2	
		13,721	0.40	24	61	0.018	25	3.6	
	Occ.	13,721	0.40	8	151	0.018	35	4.2	15.0
2	Second Floor	11,896	0.40	16	151	0.018	30	6.2	
		11,896	0.40	24	61	0.018	25	3.1	
	Occ.	11,896	0.40	8	151	0.018	35	3.6	13.0
							Infiltration Total		27.9

HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	First Floor	Roof 1	0.063	0		0
		Wall 1	0.240	1,346		323
		Doors 1	0.690	72		50
		Windows 1	0.490	152		74
		Floor	0.148	1,525		226
					Wing UA Total	673.2
2	Second Floor	Roof 1	0.061	1,355		82
		Roof 2	0.087	150		13
				1,525		0
		Wall 1	0.240	1,136		272
		Attic Door 2	0.304	20		6
		Windows 1	0.490	209		102
		Floor	0.148	0		0
					Wing UA Total	476.2
					Building Total UA:	1149.4

Temperature & Schedule Information

Building Name: **Town Offices**

	Total Heating Days	212			Floor SF		
	Outdoor Winter Temperature	35			3,049		

					Htg		
					System		Occ Level
	Wing name	**Occupied**	**Unoccupied Temp.**		**Occ. Hrs**		**Heating**
		Temp.	**Night**	**Off days**	**per day ***	**Schedule**	**Days**
1	First Floor	70	65	60	8	5 days per week	151
2	Second Floor	70	65	60	8	5 days per week	151

HEAT LOADS
AFTER
ATTIC INSULATION

ENVELOPE ECM:	HEAT LOADS AFTER		
HEAT LOADS AFTER ATTIC INSULATION			
GAINS AND LOSSES	**BTU/HEATING SEASON*1E6**		
CONDUCTION LOSSES		156.8	**Total**
INFILTRATION LOSSES		24.4	**Losses**
VENTILATION LOSSES		0.0	**181.2**

ATTIC	ENVELOPE ECM:	HEAT LOSS COEFFICIENTS				
Zone #	**Building Zone**		**U-Value (BTU/hr-sf-F)**	**Area (sf)**		**UA-Value (BTU/hr-F)**
1	**First Floor**	Roof 1	0.016	0		0
		Wall 1	0.240	1,346		323
		Doors 1	0.690	72		50
		Windows 1	0.490	152		74
		Floor	0.148	1,525		226
				Wing UA Total	**673.2**	
2	**Second Floor**	Roof 1	0.016	1,375		21
		Roof 2	0.015	150		2
		Wall 1	0.240	932		223
		Wall 2	0.036	204		7
		Attic Door 2	0.304	20		6
		Windows 1	0.490	209		102
		Floor	0.148	0		0
				Wing UA Total	**362.8**	
				Building Total UA:	**1036.1**	

ENVELOPE ECM: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	First Floor	673	8	151	35	28	
		673	16	151	30	49	
		673	24	61	25	25	101.9
2	Second Floor	363	8	151	35	15	
		363	16	151	30	26	
		363	24	61	25	13	54.9
	Total UA	1,036		Conduction Total			156.8

ENVELOPE ECM: INFILTRATION LOSSES

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	First Floor	13,721	0.35	16	151	0.018	30	6.3	
		13,721	0.35	24	61	0.018	25	3.2	
	Occ.	13,721	0.35	8	151	0.018	35	3.7	13.1
2	Second Floor	11,896	0.35	16	151	0.018	30	5.4	
		11,896	0.35	24	61	0.018	25	2.7	
	Occ.	11,896	0.35	8	151	0.018	35	3.2	11.3
						Infiltration Total			24.4