BALES ENERGY ASSOCIATES

ENERGY STUDY
For the
Ashby Highway Department
DPW Building 1

Date: October 21, 2014
(Revised 12/5/14)

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

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Table of Contents

Introduction

Bales Energy Associates, an energy efficiency engineering firm, was contracted to provide an energy study for selected town-owned buildings in Ashby, Massachusetts. The study was funded through grant funds provided by the Green Communities Program of the Massachusetts Clean Energy Center. The building evaluated in this report is Building 1 of the Highway Department, the primary structure housing the office and main maintenance garage bays. It is located at 92 Breed Road.

Bart Bales, PE, MSME, senior engineer at BEA, visited the site, reviewed energy usage and 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.

Note: Through the course of this study, BEA has evaluated specific system improvement opportunities including building enclosure, HVAC, controls, domestic hot water and other mechanical and electrical systems. This analysis was completed to a level sufficient for recommending and calculating potential energy and dollar savings and for estimating costs for recommended energy system improvements to aid the client in making an informed decision on implementation of the recommendations provided.

Disclaimer: An added design phase for development of final design documents for construction implementation is assumed and recommended to follow this report. This study may be used as a starting point with supporting information for development of final system design and specification documents. Verification of all field measurements and recalculation of all heat load and final system sizing calculations are the responsibility of the final designer of record. Design implementation may be accomplished by any of the following methods: plan-specification-bid process or performance specification-design-build process.

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 II calculations were completed for all measures evaluated.

Heating and enclosure system improvements were the focus of the study at this Highway Department Facility.

Key conclusions are the following:

1. **Enclosure Systems Recommendation**
   Re-install existing insulation that has become detached.

2. **Heating System Replacement**
   Replace existing heating system with a propane-fired condensing unit heater. Install town-owned propane tank. (Note: This tank will also be used to serve DPW Building #2.)

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

Natural Gas	Propane	Oil	Electricity
per therm	$2.05 per gal	$3.30 per gal	per kWh

Executive Summary Chart

Green Communities Study

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Available Incentive ($)	Fuel Energy Savings (% of base)	Annual Savings ($ / yr)	Full Cost				Incremental Cost Difference *			
					Cost ($)	Payback (yrs)	After Incentive Cost ($)	After Incentive Payback (yrs)	Cost ($)	Payback (yrs)	After Incentive Cost ($)	After Incentive Payback (yrs)
ECM 1	Enclosure ECM	$ -	2%	$ 149	$ 480	3.2	$ 480	3.2	$ 480	3.2	$ 480	3.2
ECM 2	Heat With Condensing Unit Heater	$ -	17%	$ 1,801	$ 10,309	5.7	$ 10,309	5.7	$ 7,521	4.2	$ 7,521	4.2
	Totals:	*$ -*	19%	*$ 1,950*	*$ 10,789*	*5.5*	*$ 10,789*	*5.5*	*$ 8,001*	*4.1*	*$ 8,001*	*4.1*

*Incremental = (Full Cost) - (Replacement-In-Kind of Existing)

Fuel Energy Impact

Natural Gas	Propane	Oil	Electricity
100.0 kBtu / therm	92.5 kBtu / gal	138.7 kBtu / gal	3.413 kBtu / kWh

Baseline Energy Use	Natural Gas	Propane	Oil	Electricity	Fuel Energy
Space Heating			2,441		338,539

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures: Natural Gas (therm / yr)	Propane (gal / yr)	Oil (gal / yr)	Electricity (kWh / yr)	Fuel Energy Use (kBtu / yr)	Fuel Energy Savings (kBtu / yr)	Savings As % of Baseline
ECM 1	Enclosure ECM			2,396		332,267	6,272	2%
ECM 2	Heat With Condensing Unit Heater		2,981			275,760	56,507	17%
					Totals:	*62,779*	*19%*	

Existing Conditions

Facility Description

The Highway Department facility's main function is to serve as an office space, maintenance garage and vehicle/equipment storage space for the town's highway department. This building, one of two on the property, is a single story, metal fabricated, slab-on-grade structure that comprises three large garage areas and the department's office space. These garage bays serve as the regular maintenance areas and are the 'high use' bays for the department, as the second building is mostly used for enclosed storage of trucks and equipment. There is a modest office space, approximately 12' x 16', located in the south (front right) corner.

Utility Energy Use

Utility data for a multi-year period was collected. Data for the reference year used, May 2013 - April 2014, is tabulated and reported in the appendices. The electrical usage was 9,367 kWh and the #2 fuel oil consumption was 2,441 gallons for that time period. These utility/fuel values result in annual totals of 370,499 kBtu and 131.9 kBtu/ft^2.

Building Enclosure

The building has a low sloped, rubber membrane roof on a plywood deck over a 2 x 8 wood rafter cathedral ceiling insulated with approximately 7.5" of fiberglass batt insulation in the rafter bays. Exterior walls are corrugated metal on a steel frame with a 1" layer of rigid foam on the inside face of the metal siding, though there were areas where the insulation had been compromised and should be repaired as necessary. Other than the major enclosure penetrations at the garage doors, there are limited other penetrations, including a gable end fan and vent (one on either side) and the chimney stack from the unit heater. The only windows are the small double pane units integrated in one section of the three 12' x 12' overhead garage bay doors. The overhead doors are insulated doors.

Below is a picture taken of the interior of the main maintenance garage showing the basic construction details.

Heating, Ventilating & Air Conditioning Systems

Unit Heater

The main DPW building is served by a relatively new oil-fired ceiling suspended unit heater. The unit is a Modine model POR185, installed in 2010. It has an oil input rate of 1.65 GPH (approx. 228 MBH), a listed efficiency rating of 81%, and provides an output of approximately 185 MBH.

An exhaust vent fan was installed in the gable wall (along with a paired, motorized louver on the other gable wall) for the purpose of removing harmful vehicle fumes during times when the space is being heated and the garage doors are closed. It is used on an as-needed basis and is manually operated by the maintenance staff.

The design heat load for this building is approximately 141,000 Btu/hr.

Heating Distribution System

The installed unit heater is not connected to any ducted distribution and therefore simply takes return air in the rear of the unit, heats it, and blows it across slanted fins on the front to circulate it back to the space. There is a single ceiling fan installed that, if used during the heating season, would assist in de-stratifying the heated air from the ceiling and help circulate it down to the occupied space near the floor, potentially improving occupant comfort.

Cooling System

There is currently no cooling equipment utilized at the Highway Department facilities.

Temperature & Ventilation Control System

The highway department staff installed a programmable thermostat sometime during the 2013-2014 heating season and indicated a plan to program it for 65˚ for occupied daytime temperature and setback to 55˚ during the unoccupied hours.

Domestic Hot Water System

An electric hot water tank serves the DHW demand at the Highway Department. Water use is modest, mainly for hand washing and occasional limited use for washing of tools and equipment. No recommendation is made with regard to domestic hot water.

APPENDICES

UTILITY INFORMATION

May 2013 - Apr 2014 Billed Energy Use Table for Electricity & Fuel

Building Name	**Highway Dept - Building 1**							
Owner	**Town of Ashby**							
Account #								
Month	Electricity KWH	Billed Demand KW	Delivery Charged $	Supplier Charged $	Electricity Total $	Oil Gallons	Oil $	**Energy $ Totals**
May 2013	649	5.5	$113	$41	$155			**$155**
Jun	640	6.5	$121	$45	$166			**$166**
Jul	655	5.0	$105	$50	$154			**$154**
Aug	666	5.0	$105	$51	$156			**$156**
Sept	708	6.0	$117	$50	$166			**$166**
Oct	628	4.5	$95	$43	$138			**$138**
Nov	807	4.5	$106	$57	$163	341.6	$1,086	**$1,249**
Dec	913	5.0	$118	$84	$202	452.6	$1,491	**$1,693**
Jan 2014	969	6.0	$133	$108	$242	554.4	$1,864	**$2,105**
Feb	1,064	5.0	$129	$124	$253	521.7	$1,787	**$2,040**
Mar	902	5.5	$124	$78	$202	434.1	$1,401	**$1,603**
Apr 2014	766	5.0	$110	$55	$165	136.4	$432	**$597**
Annual (Units)	9,367		$1,375	$785	$2,161	2,441	$8,062	**$10,223**
Heating Season (Units)	6,049		$815	$549	$1,364	2,441	$8,062	**$9,425**
Annual ($/Unit)			$0.15	$0.08	$0.23		$3.30	
Heating Season ($/Unit)			$0.13	$0.09	$0.23		$3.30	
	Electricity kBtu					**Oil kBtu**	**Energy Use Totals (kBtu)**	
Annual (kBtu)	31,960					338,539	370,499	**Energy $ Totals**
Heating Season (kBtu)	20,639					338,539	359,178	
							Totals (kBtu/sf)	**($/sf)**
Annual (kBtu/sf)	11.4					120.6	**131.9**	**$3.64**
Heating Season (kBtu/sf)	7.4					120.6	**127.9**	**$3.36**
Building Name	**Highway Dept - Building 1**						**Heated Square Footage**	**2,808**

ECM 1:
ENCLOSURE MEASURE

Summary of Energy Savings					
ECM 1	**Wall Insulation & Air Sealing**				
	Baseline	**After ECM 2**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	262.7	257.8	4.87	1.9%	
Existing Seasonal System Efficiency	78%	78%			
Fuel Energy Usage (MMBtu/yr)	338.5	332.3			
Energy Savings	**% Reduction**	**Fuel Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
	1.9%	2,441	45	$3.30	$149
				Total Savings	**$149**

Cost	Savings	Payback (yr)
$480	**$149**	**3.2**

Note:

	# hrs.	$ / hr.	Cost ($)
Replace falling insulation	8	$40	$ 320
Air Sealing	4	$40	$ 160
	Totals	***40***	***$ 480***

ECM 2:
HEATING SYSTEM MEASURE

ECM # 2 — **Space Heating Savings with Condensing, Propane-fired Unit Heater**
Highway Dept - Building 1

Fuel Rate ($/gallon)					Propane Rate ($/gallon)	
$3.30	**Existing Condition:**			**New Condition:**	$2.05	
Equipment Type	**Space Heating Unit Heater**			**Space Heating Unit Heater**		
Boiler #	1			1		
Make	Modine			Modine		
Model	POR185B			PTC 215		
Type	Atmospheric			Condensing		
Heating Medium	Air			Air		
Control Mode	on / off			on / off single stage		
Output kBtu/Hr	185			200		
Steady State Eff	81%			93%		
Input kBtu/Hr	229			215		
Seasonal Eff	78%			91%		
Percentage of Load	121%			131%		

Replacement-In-Kind Costs		**Installed System Costs**		
Boiler	$2,788	**Condensing Unit Heater**	$ 3,280	*(stainless steel, secondary heat exchanger)*
		Installation	$ 1,870	
		Propane storage tank	$ 2,600	
		Wifi Capable Programmable Thermostat	$ 770	
			$ 8,520	***Subtotal***
		Contingency	$ 852	
			$ 9,372	***Subtotal***
		Contractor Oversight	$ 937	
Totals	**$2,788**	***Total:***	***$ 10,309***	

Summary of Existing Building-Related Heat Loads	**Annual Building Operating Load (kBtu / year)**	**Projected Fuel Usage Gallons**	**New Propane Usage Gallons**	**Fuel Cost**	**Peak Space Heating Load (kBtu / hr)**	**Provide (#) 1 Boiler @ 100% of design Load**
Space Heating Load	**250,942**	**2,396**		**$7,912**	**153**	**153**
	250,942		**2,981**	**$6,111**		
			Savings $	**$1,801**		

	Cost	**Savings**	**Payback**
Full Equipment Cost Basis:	**$10,309**	**$1,801**	**5.7**
Incremental Equipment Cost Difference:	**$7,521**	**$1,801**	**4.2**

GREENHOUSE GAS EMMISSIONS

Greenhouse Gas (GHG) Impact

Baseline Fuel Usage	Natural Gas	Propane	Oil	Electricity	MT eCO2
Space Heating			2,441		25.1

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures: Natural Gas (therms / yr)	Propane (gal / yr)	Oil (gal / yr)	Electricity (kWh / yr)	GHG Emmissions (MT eCO2)	GHG Savings (MT eCO2)	Savings As % of Baseline
ECM 1	Enclosure ECM			2,396		24.7	0.5	2%
ECM 2	Heat With Condensing Unit Heater		2,981			16	9	35%
						Totals:	***9***	***37%***

GHG Emmissions		
10.3	MT eCO2 / 1,000	gallons of #2 Fuel Oil
5.3	MT eCO2 / 1,000	gallons of Propane (LPG)
14.1	MT eCO2 / 100	short ton of wood pellets (2,000 lbs.)
333.7	MT eCO2 / 1,000,000	kWh of electricity
per Clean Air Cool Planet Campus Carbon Calculator (2013 value)		

HEAT BALANCE INFORMATION

BASELINE: HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-222.6
INFILTRATION LOSSES	-67.9
VENTILATION LOSSES	0.0
SOLAR GAIN	7.6
OCCUPANT GAIN	0.6
ELECTRICAL GAIN	19.6
NET HEATING DEMAND	-262.7

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
262.7	338.5	78%

BASELINE: Temperature & Schedule Information

Building Name: Highway Dept - Building 1

Total Heating Days	212	Floor SF	
Outdoor Winter Temperature	35	2,808	

	Wing name	Occupied Temp.	Unoccupied Temp. Night	Unoccupied Temp. Off days	Htg System Occ. Hrs per day *	Schedule	Occ Level Heating Days
1	Whole Facility	68	68	68	8	5 days per week	151

BASELINE: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Whole Facility	1,326	8	151	33	53	
		1,326	16	151	33	106	
		1,326	24	61	33	64	222.6
	Total UA	1,326			Conduction Total		222.6

BASELINE: INFILTRATION LOSSES

0.55

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Whole Facility	37,620	0.55	16	151	0.018	33	29.7	
		37,620	0.55	24	61	0.018	33	18.0	
	Occ.	37,620	0.75	8	151	0.018	33	20.2	67.9
							Infiltration Total		67.9