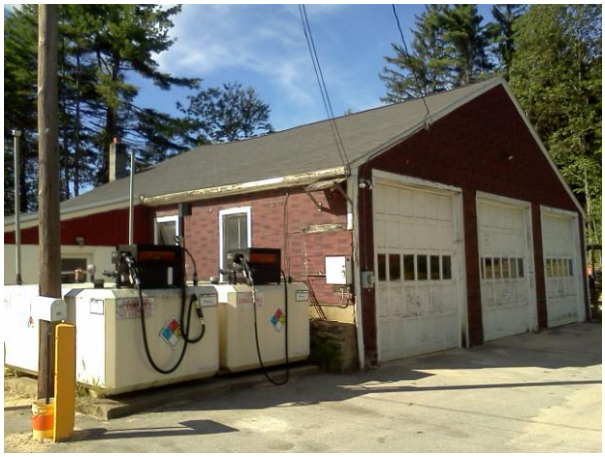
BALES ENERGY ASSOCIATES

ENERGY STUDY
for the
Ashby Highway Department
DPW Building 2



Date: October 21, 2014
Revised: December 19, 2014

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

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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 Ashby, 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 Building 2 of the Highway Department, the auxiliary, slightly older structure used for vehicle & equipment storage, which is located on 92 Breed Road.

Bart Bales, PE, MSME, senior engineer at BEA, 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.

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 facility of the Ashby Highway Department.

Key conclusions are the following:

1. **Enclosure Improvements** can substantially reduce the building's heat loss characteristics. Recommendations include:
   - **Replace missing and damaged wall insulation with R-13 fiberglass.**

2. **Heating System Improvements**:
   - **Replace the existing furnace with:**
     1. **A propane-fired, condensing unit heater: Installed in and provide heat for the garage bay area.**
     2. **A propane-fired, direct-vent wall heater: Installed in the 'old office' section of the building.**

The costs, savings, and economic payback for these energy conservation measures are presented in the following Executive Summary Chart. 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 *			
							After Incentive				After Incentive	
					Cost ($)	Payback (yrs)	Cost ($)	Payback (yrs)	Cost ($)	Payback (yrs)	Cost ($)	Payback (yrs)
ECM 1	Wall Insulation & Air Sealing	$ -	25%	$ 1,461	$ 3,291	2.3	$ 3,291	2.3	$ 3,291	2.3	$ 3,291	2.3
ECM 2	Space Heating: Propane-fired Heaters	$ -	16%	$ 1,159	$ 12,675	10.9	$ 12,675	10.9	$ 9,690	8.4	$ 9,690	8.4
	Totals:	*$ -*	*41%*	*$ 2,620*	*$ 15,966*	*6.1*	*$ 15,966*	*6.1*	*$ 12,981*	*5.0*	*$ 12,981*	*5.0*

*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			1,746		242,219

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures				Fuel Energy Use	Fuel Energy Savings	Savings As % of Baseline
		Natural Gas (therm / yr)	Propane (gal / yr)	Oil (gal / yr)	Electricity (kWh / yr)	(kBtu / yr)	(kBtu / yr)	
ECM 1	Wall Insulation & Air Sealing			1,304		180,897	61,322	25%
ECM 2	Space Heating: Propane-fired Heaters		1,537			142,176	38,721	16%
						Totals:	*100,043*	*41%*

Existing Conditions

Facility Description

This building of the Highway Department serves mainly as a garage/storage facility for vehicles and equipment and is occasionally used for maintenance work as necessary. The vehicle fuel tanks and pumps are located immediately next to this building. The old office, currently functioning as the mechanical room of the building, needs to be heated to protect some equipment from damage which would result from freezing. It is a single story building built on a concrete slab.

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 1,453 kWh and the #2 fuel oil consumption was 1,971 gallons for that time period. These utility/fuel values result in annual totals of 278,308 kBtu and 145 kBtu/ft^2.

Building Enclosure

The building has a low sloped, asphalt shingled roof over a ceiling insulated with foil-faced fiberglass between the rafter bays. Exterior walls are a wood frame structure set on top of a small stone wall extending a few feet up from the concrete slab. There was fiberglass insulation in the walls at one time, though most had been removed by the time of the site visit. The limited insulation that still remained was in very poor condition. (For the purposes of the energy calculations in this report, the walls were assumed to be un-insulated.) There are a small number of single paned windows spaced throughout. The building has three overhead garage bay doors. The overhead doors are older, poor efficiency wood doors with little to no insulating value.

Below is a picture taken of the interior of the garage bays heated with the oil furnace.

Recommendation: Replace Wall Insulation

Bales Energy Associates recommends re-insulating al walls with new R-13 fiberglass insulation. This will be installed in the typical manner, between wood framing members. Also, given the nature of the work conducted in this space, BEA recommends consideration of installation a tear-resistant, reinforced membrane over the fiberglass, across the framing members, to aid in prolonging the life of the new insulation. Prior to the installation of the added insulation, BEA recommends air sealing to reduce air infiltration into the conditioned space from outside. In addition, BEA recommends replacing any missing or damaged ceiling insulation. (Most of the ceiling insulation in the main bays was in place, though there were areas in the old office space (where the furnace is currently located) where the insulation had fallen.)

Heating, Ventilating & Air Conditioning Systems

Heating System

The secondary DPW building is served by an oil-fired hot air furnace. The unit is a Metromatic MFG Co. furnace (model: LB-200) with a rated fuel input of 1.75 GPH, producing an output of 204 kBtu/hr that results in an efficiency of approximately 83%.

The design heat load for the entire facility, in its existing condition, was modeled at approximately 136,000 Btu/hr. System sizing for the new heating equipment was based upon the heat load after the enclosure measures were implemented.

Heating Distribution

The heating distribution system consists of hot air supply and return ducting.

Cooling System

There is currently no cooling equipment used in this facility.

Temperature & Ventilation Control System

The existing thermostat control is a manually adjusted thermostat. The staff indicated a consistent, year-round set point of 58˚F for the system.

Domestic Hot Water (DHW) System

There is no DHW use in this building.

APPENDICES

UTILITY INFORMATION

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

Building Name	**Highway Dept - Building 2**						
Owner	**Town of Ashby**						
Month	Electricity KWH	Delivery Charged $	Supplier Charged $	Electricity Total $	Oil Gallons	Oil $	**Energy $ Totals**
May 2013	30	$12	$2	$14			**$14**
Jun	9	$9	$1	$10			**$10**
Jul	23	$11	$2	$13			**$13**
Aug	28	$12	$2	$14			**$14**
Sept	28	$12	$2	$14			**$14**
Oct	24	$13	$2	$15			**$15**
Nov	117	$13	$9	$23	211.6	$676	**$699**
Dec	194	$14	$17	$31	372.4	$1,226	**$1,258**
Jan 2014	281	$15	$26	$41	484.0	$1,624	**$1,665**
Feb	313	$15	$29	$44	421.5	$1,442	**$1,486**
Mar	296	$16	$27	$43	362.0	$1,166	**$1,209**
Apr 2014	110	$16	$10	$27	119.3	$378	**$404**
Annual (Units)	1,453	$158	$75	$288	1,971	$6,513	**$6,801**
Heating Season (Units)	1,335	$102	$121	$223	1,971	$6,513	**$6,736**
Annual ($/Unit)		$0.15	$0.07	$0.20		$3.30	
Heating Season ($/Unit)		$0.11	$0.13	$0.17		$3.30	
	Electricity kBtu				**Oil kBtu**	**Energy Use Totals (kBtu)**	
Annual (kBtu)	4,958				273,350	278,308	**Energy $ Totals**
Heating Season (kBtu)	4,555				273,350	277,905	
						Totals (kBtu/sf)	**($/sf)**
Annual (kBtu/sf)	2.6				142.4	**145.0**	**$3.54**
Heating Season (kBtu/sf)	2.4				142.4	**144.8**	**$3.51**
Building Name	**Highway Dept - Building 2**					**Heated Square Footage**	**1,919**

BUILDING HEAT BALANCE

BASELINE: HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-153.6
INFILTRATION LOSSES	-31.4
VENTILATION LOSSES	0.0
SOLAR GAIN	11.2
OCCUPANT GAIN	0.0
ELECTRICAL GAIN	4.3
NET HEATING DEMAND	-169.4

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
169.4	242.2	70%

BASELINE: Temperature & Schedule Information

Building Name: Highway Dept - Building 2

Total Heating Days	212	Floor SF	
Outdoor Winter Temperature	35	1,919	

	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	58	58	58	8	5 days per week	151

BASELINE: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Whole Facility	1,312	8	151	23	36	
		1,312	16	151	23	73	
		1,312	24	61	23	44	153.6
	Total UA	1,312			Conduction Total		153.6

BASELINE: INFILTRATION LOSSES

0.6

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Whole Facility	23,892	0.60	16	151	0.018	23	14.3	
		23,892	0.60	24	61	0.018	23	8.7	
	Occ.	23,892	0.70	8	151	0.018	23	8.4	31.4
							Infiltration Total		31.4

ENCLOSURE MEASURE

Summary of Energy Savings					
ECM 1	**Wall Insulation & Air Sealing**				
	Baseline	**After ECM 1**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	169.4	126.5	42.89	25.3%	
Existing Seasonal System Efficiency	70%	70%			
Fuel Energy Usage (MMBtu/yr)	242.2	180.9			
Energy Savings	**% Reduction**	**Fuel Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
	25.3%	1,746	442	$3.30	$1,461
				Total Savings	**$1,461**

Cost	Savings	Payback (yr)
$3,291	**$1,461**	**2.3**

Note:

Insulate Walls of Garage Bays 791 sq.ft.

	Depth (in.)	R-value		Cost ($)
Fiberglass Batt	3.5	13	$	2,435
			$	-
Air Sealing			$	285
		Subtotal	***$***	***2,720***
		Contingency	*$*	*272*
		Subtotal	***$***	***2,992***
		Contractor Oversight	*$*	*299*
		TOTAL	**$**	**3,291**

HEATING SYSTEM MEASURE

ECM # 2 — **Space Heating: Propane-fired Heaters**
Highway Dept - Building 2

Fuel Rate ($/gallon)					Propane Rate ($/gallon)	
$3.30	**Existing Condition:**			**New Condition:**	$2.05	
Equipment Type	**Space Heating Furnace**			**Space Heating Unit Heater**	**Space Heating Wall Heater**	
Furnace #	1			1	1	
Make	Metromatic			Modine	Rinnai	
Model	LB 200			PTC 110	EX17C	
Type	Atmospheric			Condensing	Concentric/Direct-vent	
Heating Medium	Air			Air	Air	
Control Mode				Modulating		
Output kBtu/Hr	204			102	13.7	
Steady State Eff	84%			93%	82%	
Input kBtu/Hr	243			110	16.7	
Seasonal Eff	70%			90%	80%	
Percentage of Load	187%			94%	13%	

Replacement-In-Kind Costs		**Installed System Costs**		
Furnace	$2,985	**Condensing Unit Heater**	$3,375	
		Direct-vent Wall Heater	$1,600	
		Propane Line Piping	$300	
			$5,275	***Materials Subtotal***
		Installation Including Removal of Existing Equipment	$5,200	
			$10,475	***Subtotal***
		Contingency	$1,048	
			$11,523	***Subtotal***
		Contractor Oversight	$1,152	
Totals	**$2,985**	***Total:***	**$12,675**	

Summary of Existing Building-Related Heat Loads	**Annual Building Operating Load (kBtu/year)**	**Projected Oil Usage After ECM 1 Gallons**	**New Propane Usage Gallons**	**Fuel Cost**	**Peak Space Heating Load (kBtu/hr)**	**Provide (#) 2 Heaters @ 106% of design Load**
Space Heating Load	**126,537**	**1,304**		**$4,310**	**109**	**116**
	126,537		**1,537**	**$3,151**		
			Savings $	**$1,159**		

	Cost	**Savings**	**Payback**
Full Equipment Cost Basis:	**$12,675**	**$1,159**	**10.9**
Incremental Equipment Cost Difference:	**$9,690**	**$1,159**	**8.4**

GREENHOUSE GAS EMMISSIONS

Greenhouse Gas (GHG) Impact

Baseline Fuel Usage	Natural Gas	Propane	Oil	Electricity	MT eCO2
Space Heating			1,746		18

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	Wall Insulation & Air Sealing			1,304		13	5	25%
ECM 2	Space Heating: Propane-fired Heaters		1,537			8	5	29%
						Totals:	*10*	*55%*

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)		