

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

Completed By:

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Table of Contents

Introduction	3
Executive Summary	3
Energy Conservation Opportunities Evaluated	3
Executive Summary Chart	4
Existing Conditions	1
Facility Description	4
Utility Energy Use	5
Building Enclosure	5
Heating, Ventilating & Air Conditioning Systems	5
Unit Heater	5
Heating Distribution System	6
Cooling System	6
Temperature & Ventilation Control System	5
Domestic Hot Water System	5
APPENDICES	7
UTILITY INFORMATION	8
ECM 1: ENCLOSURE MEASURE 10	0
ECM 2: HEATING SYSTEM MEASURE 1	1
GREENHOUSE GAS EMMISSIONS12	2
HEAT BALANCE INFORMATION1	3

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			Executi	ve Summai	y Chart]				
	per therm	\$2.05 per gal	\$3.30 per gal	per kWh			Gree	n Communities S	Study]				
	Me	asure Descript	tion		Fuel Energy	Annual		Full C	lost			Incremental (Cost Difference	*
Measure		newable Thermal	· ·	Available	Savings	Savings			After I	ncentive			After I	ncentive
#	(ECM = End	ergy Conservation	n Measure)	Incentive (\$)	(% of base)	(\$ / yr)	Cost (\$)	Payback (yrs)	Cost (\$)	Payback (yrs)	Cost (\$)	Payback (yrs)	Cost (\$)	Payback (yrs)
ECM 1	Enclosure EC!	M		\$-	2%	\$ 149	\$ 480	3.2	\$ 480	3.2	\$ 480	3.2	\$ 480	3.2
ECM 2	Heat With Cor	ndensing Unit I	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 Ill Cost) - (Replaceme	\$ 8,001	

			Fuel Energ	gy Impact				
		Natural Gas	Propane	Oil	Electricity			
		100.0	92.5	138.7	3.413			
		kBtu / therm	kBtu / gal	kBtu / gal	kBtu / kWh			
				r	,	·		
	Baseline Energy Use	Natural Gas	Propane	Oil	Electricity	Fuel Energy		
	Space Heating			2,441		338,539		
	Measure Description		Fuel Usage Af	ter Measures		Fuel Energy	Fuel Energy	Savings
Measure	Measure Description (RTM = Renewable Thermal Measure)	Natural Gas	Fuel Usage Aft Propane	ter Measures Oil	Electricity	Fuel Energy Use	Fuel Energy Savings	Savings As % of
Measure #	-		0		Electricity (kWh / yr)	0.	0.	6
	(RTM = Renewable Thermal Measure)	Natural Gas	Propane	Oil	· ·	Use	Savings	As % of
	(RTM = Renewable Thermal Measure)	Natural Gas	Propane	Oil	· ·	Use	Savings	As % of
#	(RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Natural Gas	Propane	Oil (gal/yr)	· ·	Use (kBtu / yr)	Savings (kBtu / yr)	As % of Baseline
# ECM 1	(RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure) Enclosure ECM	Natural Gas	Propane (gal / yr)	Oil (gal/yr)	· ·	Use (kBtu / yr) 332,267	Savings (kBtu / yr) 6,272	As % of Baseline 2%

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/ft².

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
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Billed Energy Use Table for Electricity & Fuel

Building Name	Highway Dep							
Owner	Town of Ashl	ру						
	-							
Account #								
	Electricity	Billed Demand	Delivery	Supplier	Electricity	Oil	Oil	Energy \$
Month	KWH	KW	Charged \$	Charged \$	Total \$	Gallons	\$	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
		0.0		, ,,,,	\$ 100		¢ .0_	
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			•		Oil	Energy Use	
	kBtu					kBtu	Totals (kBtu)	
Annual (kBtu)	31,960					338,539	370,499	Energy \$
Heating Season (kBtu)	20,639					338,539	359,178	Totals
		-			_		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 Dep	t - Building 1				Heated	Square Footage	2,808

ECM 1: ENCLOSURE MEASURE

	Summary of E	nergy Saving	S		
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
			T	otal Savings	\$149
				_	
	Cost	Savings	Payback (yr)		
	\$480	\$149	3.2		
Note:					

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

ECM 2: HEATING SYSTEM MEASURE

Building-Related Load Usage Usage Fuel Load 100 Heat Loads (kBtu / year) Gallons Gallons Cost (kBtu / hr) of design	ECM # 2	Space Hea		ith Condensing, P		tHeater	
\$3.30 Existing Condition: New Condition: \$2.05 Equipment Type Space Heating Space Heating Image: Sp			Hig	hway Dept - Buildi	ng 1	r	1
Equipment Type Unit Heater Spec Heating Spec Heating Boiler # 1 1 1 1 Make Modie 1 1 1 1 Make Modie Modie 1 1 1 Make Model PORS5B PTC 215 1 1 Model PORS5B Condersing 1 1 1 1 Control Mode on / off 0 - On / off single stage 1 1 1 1 Output kBtuffr 185 200 215 93% 1	Fuel Rate (\$/gallon)					Propane Rate (\$/gallon)	
Equipment Type Unit Heater Unit Heater Boller # 1 1 1 Make Modine Modine 1 1 Make Modine Modine 1 1 1 Make Modine Modine Modine 1 1 1 Make POR185B Condensing 1 1 1 1 1 Model POR185B Condensing 1 1 1 1 1 1 Model Ontrait Khurfir 185 0 010 1 <td< td=""><td>\$3.30</td><td>Existing Condition:</td><td></td><td></td><td>New Condition:</td><td>\$2.05</td><td></td></td<>	\$3.30	Existing Condition:			New Condition:	\$2.05	
Boiler # 1 1 1 Make Modie Modie Modie Modie Modie Model POR185B PTC 215 Important Modie Ar Type Annopheric Condensing Import Mode Ar Control Mode on / off Output kBut/Ir 155 200 Import Mathematication Import Mathemathematication Import Mathemathema							
Make Modine Modine Model POR1858 PTC 215 Type Attraspheric Condersing Heating Medium Air Air Control Mode on / off on / off single stage	Equipment Type	Unit Heater			Unit Heater		
Model POR1858 POR1858 PTC 215 PTC 215 Type Atmospheric Condensing PTC 215 PTC 215 Heating Medium Air Air PTC 215 PTC 215 Control Mode on / off State Eff PTC 215 PTC 215 Output kBtu/Hr 185 200 PTC 215 PTC 215 Output kBtu/Hr 185 99% PTC 215 PTC 215 State Eff 81% 99% PTC 215 PTC 215 PTC 215 State State Eff 81% 99% PTC 215 PTC 215 PTC 215 State State Eff 78% 91% PTC 215 PTC 215 PTC 215 State State Eff 78% PTC 215 PTT 215 <		-			-		
Type Atmospheric Condensing Heating Medium Ar Ar Control Mode on / off 0n / off single stage Output kBtu/Ir 185 200 Steady State Eff 81% 93% Input kBtu/Ir 185 200 Steady State Eff 81% 93% Procentage of Load 121% 11% Percentage of Load 121% 131% Replacement In-Kind Costs Installation 1,870 Nifi Capable Programmable Thermostat \$ 770 Southout I \$ 8,520 Subtotal \$ 9,372 Subtotal \$ 9,372 Totals \$ 2,788 Contractor Oversign \$ 9,372 Subtotal \$ 10,309 Building Projected Fuel Propane Load (kBtu / hr) Building Cost Salotal \$ 10,309 Space Heating Load 100							
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Control Mode on / off on / off on / off single stage on / off single stage Output kBu/Hr 185 200	7.4	<u>^</u>			0		
Output kBtu/Hr 185 200 1 Steady State Eff 81% 93% 1 1 Input kBtu/Hr 229 215 1 1 Seasonal Eff 78% 93% 1 1 Percentage of Load 121% 131% 1 1 Replacement-In-Kind Costs Installed System Costs 3.280 (stainless steel, secondary heat excharger) Boiler \$2,788 Condensing Unit Heater \$3,280 (stainless steel, secondary heat excharger) Wiff Capable Programmable Thermostat \$770 \$ \$,8,520 Subtotal Summary of Annual Projected New \$ \$,9,372 Summary of Annual Projected New \$ \$,9,372 Building Operating Fuel Propane Heating \$,000 Summary of Annual Building Projected New \$,000 \$,000 \$,000 Heat Loads (kBtn / year) Gallons Gallons Cost \$	Heating Medium	Air			Air		
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Cost Savings Payback Full Equipment Cost Basis: \$10,309 \$1,801 5.7				Savings \$	\$1,801		•
ull Equipment Cost Basis: \$10,309 \$1,801 5.7					· · /		
Sull Equipment Cost Basis: \$10,309 \$1,801 5.7		[Cost	Savings	Pavhack		
	ull Equipment Cost Basis			0	, v		
ncremental Equipment Cost Difference: \$7,521 \$1,801 4.2	un Equipric în Cost Dusis.		φ10,507	φ1,001	5.7		
ncremental Bouinment Lost Lutterence? \$7.571 \$1.81.801 4.7		ee	¢7.501	\$1.901	4.2		
	ncremental Equipment Cost Di	iierence:	\$7,521	\$1,801	4.2		

GREENHOUSE GAS EMMISSIONS

	(Greenhous	e Gas (G	HG) Impa	lct			
	Baseline Fuel Usage	Natural Gas	Propane	Oil	Electricity	MT eCO2		
	Space Heating			2,441		25.1		
	Measure Description	Fuel Us	age After M	easures		GHG	GHG	Savings
Measure	(RTM = Renewable Thermal Measure)	Natural Gas	Propane	Oil	Electricity	Emmissions	Savings	As % of
#	(ECM = Energy Conservation Measure)	(therms / yr)	(gal/yr)	(gal/yr)	(kWh / yr)	(MT eCO2)	(MT eCO2)	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 Emmi	ssions	
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 A	ir Cool Planet Campus	Carbon Calculator (2013 value)

HEAT BALANCE INFORMATION

	BASELINI	E:	HEAT BA	LANCE
GAINS AND L	OSSES	BTU/HEA	TING SEASO	N*1E6
CONDUCTION	LOSSES		-222.6	
INFILTRATIO	N LOSSES		-67.9	
VENTILATION	LOSSES		0.0	
SOLAR GAIN			7.6	
OCCUPANT G	AIN		0.6	
ELECTRICAL	GAIN		19.6	
NET HEAT	ING DEMA	ND	-262.7	
			•	
	Net Heating	/Energy	Seasonal	
	Demand	Required	Efficiency	
	(MMbtu)	(MMbtu)	%	
	262.7	338.5	78%	

BASELINE	2:	Temperatu	re & Schedu	le Information		
	B	uilding Name:	Highway Dept	- Building 1		
Total Heating Days	212			Floor SF		
Outdoor Winter Temperature	35			2,808		
				Htg		
				Htg System		Occ Level
Wing name	Occupied	Unoccupi	ed Temp.	8		Occ Level Heating
Wing name	Occupied Temp.	Unoccupi	ed Temp. Off days	System	Schedule	Occ Level Heating Days

	BASELINE:		CONDUCTION LOSSES					
			HOURS/	DAYS/	TEMP	LOSSES	Sub	
#	Zone	UA	DAY	-	DIFF	(* 1E6)	Total	
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	1	Conduction Total 222.6				

BASELINE:				INFILTRATION LOSSES						
			0.55							
				HRS/	DAYS/		TEMP	LOSSES	Sub	
#	Zone	VOLUME	ACH	DAY	YR	0.018	DIFF	(* 1E6)	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										