BALES ENERGY ASSOCIATES

Date: October 31, 2014
(Revised 12/5/14)

ENERGY STUDY
for the
Ashby Fire Station

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

Completed By:

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Introduction

Bales Energy Associates (BEA), 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 the Fire Station.

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.

BEA has approached the Ashby Fire Department building using a "whole systems thinking" approach. Improvements in various systems have interactive impacts with other systems. Key conclusions are the following:

1. **Controls Systems Recommendation**
    - **Install microprocessor-based programmable thermostats to provide temperature setback for areas. Equip with wifi capability to allow systems to be scheduled locally and remotely using "smart' phones and tablet and laptop computers.**

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 Table 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	Waste Oil	Oil	Electricity
per therm	per gal	$3.47 per gal	$0.21 per kWh

Executive Summary Chart

Green Communities Program

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	Heating System Controls	$ -	3%	$ 125	$ 1,863	14.9	$ 1,863	14.9	$ 1,863	14.9	$ 1,863	14.9
	Totals:	$ -	*0*	*$ 125*	*$ 1,863*	*14.9*	*$ 1,863*	*14.9*	*$ 1,863*	*14.9*	*$ 1,863*	*14.9*

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

Fuel Energy Impact

Natural Gas	Oil	Waste Oil	Electricity
100.0 kBtu / therm	138.7 kBtu / gal	125.0 kBtu / gal	3.413 kBtu / kWh

Baseline Energy Use	Natural Gas	Oil	Waste Oil	Electricity	Fuel Energy
Space Heating		1,240	947		290,387

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures Natural Gas (therm / yr)	Oil (gal / yr)	Waste Oil (gal / yr)	Electricity (kWh / yr)	Fuel Energy Use (kBtu / yr)	Fuel Energy Savings (kBtu / yr)	Savings As % of Baseline
ECM 1	Heating System Controls		1,204	920		281,934	8,453	3%
						Totals:	*8,453*	*3%*

Existing Conditions

Facility Description

Built in 1970, the Ashby Fire Station is a 4,288 ft^2, single story facility primarily utilized for garage storage of the department's various fleet assets. In addition to the garage space there are four additional rooms partitioned off that include the office & meeting space, a lavatory, mechanical room, and storage room. A small garage addition off the back left of the building was necessary to accommodate the additional length of a new ladder truck.

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 19,161 kWh, the #2 fuel oil consumption was 1,240 gallons, and the estimate for waste oil use was calculated to be 947 gallons for that time period. These utility/fuel values add up to annual totals of 355,764 kBtu and 83 kBtu/ft^2.

Building Enclosure

The fire station is a single-story, masonry building built on a concrete slab. The nearly flat roof, pitched very slightly to the rear center to aid in drainage/runoff control, is constructed of a rubber membrane surface with a

Fesco® board underlayment laid over roughly 2 1/2" of rigid insulation board that lies on top of a corrugated metal roof deck supported by widely spaced steel truss members. The exterior walls, and interior partition walls, are constructed of concrete masonry block. At some point a longer ladder truck was purchased and the department had to break through the back wall of the left-hand garage bay and construct a bump out garage to allow for storage of that truck. This section has a small shed roof, and is wood framed, both walls and ceiling, has an unfinished interior surface and is insulated with kraft-faced fiberglass batt insulation. The structure is supported by a standard concrete slab at grade level which is assumed to be un-insulated for this evaluation.

Below is a picture taken from the east corner of the building showing the rear of the station including the extended garage bump out addition and the detached waste oil shed.

Heating, Ventilating & Air Conditioning Systems

Heating System

The space heating is served by two Viessmann Vitorond 200 (model: VR2-40) oil-fired (#2 fuel oil) boilers located in the mechanical room and a ceiling suspended Clean Burn furnace that hangs in the garage area fired by waste oil. The two boilers have a rated output of 140 MBH each and are higher efficiency at 87%, relative to standard oil-fired, atmospheric boilers. The furnace's output is approximately 235 MBH at around 84% efficiency.

The design heat load for the existing building is approximately 235,000 Btu/hr.

It was noted that the outdoor intake grill in the exterior door of the boiler room had been sealed, presumably due to cold conditions in the boiler room. Best practice is to provide combustion air to the boilers from the outside. The consultant recommends installation of dedicated intake piping to deliver air directly to the boilers.

Cooling System

The department utilizes a removable window air conditioning unit for the meeting room space when necessary.

Temperature & Ventilating Control System

The existing thermostat controls consist of manual, round Honeywell thermostats for both heating systems. There are two zones, one is the garage bay areas and the second is the auxiliary rooms. The garage bays have two thermostats to control that area. One controls the waste oil furnace and the other controls the oil boilers. There is a third thermostat in the office/meeting room that controls that zone off the oil boilers.

Recommendation: Utilize a programmable thermostat to control temperatures and allow for automatic setback of unused areas during unoccupied hours. To allow for more effective scheduled temperature setback and building warm-up, Bales Energy recommends a programmable thermostat with wifi capability to allow activation of unscheduled building warm-up remotely using "smart' phones and tablet and laptop computers.

System costs and energy and dollar savings are reported in the appendices of this report.

HVAC Distribution System

The two heating systems have separate distribution systems associated with each one.

The oil boilers in the mechanical room have two circulators that deliver heated water through an un-insulated piping system to serve ceiling-suspended, Modine unit heaters in the garage areas and fin-tube convectors in the garage and meeting rooms.

The waste oil furnace has a duct on the discharge side of the unit. The unit's delivery system consists of a short supply plenum with supply grills on two sides which blow heated air into the garage space. A second supply trunk on the back of the plenum delivers heated air to the meeting room and the waste oil shed. The existing grill diffusers in the supply plenum serving the garage are approximately 65% covered with cardboard to direct more of the volume toward the supply trunk and ultimately the auxiliary spaces. Auxiliary spaces receiving heat from the furnace only do so when the thermostat in the garage calls for heat.

Below photo showing the ducted supply system of the waste oil furnace.

Domestic Hot Water (DHW) System

Domestic hot water is provided by a dual-element electric water heater. It was noted on the walkthrough that the copper DHW piping in the facility is not insulated and presents an opportunity for small savings, though no calculations nor specific ECM addresses this.

APPENDICES

UTILITY INFORMATION

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

Building Name	**Fire Station**								
Owner	**Town of Ashby**								
Month	Electricity KWH	Demand KW	Delivery Charged $	Supplier Charged $	Electricity Total $	Waste Oil Gallons	Oil Gallons	Oil $	**Energy $ Totals**
May 2013	1,624	11.5	$247	$104	$351		136.6	$401	**$752**
Jun	1,088	7.0	$15	$77	$92				**$92**
Jul	1,111	9.5	$183	$84	$267				**$267**
Aug	1,008	6.0	$139	$77	$215				**$215**
Sept	957	6.5	$138	$67	$205				**$205**
Oct	899	7.0	$138	$61	$199	*(estimated)*			**$199**
Nov	1,660	9.5	$212	$118	$330	947.3	182.6	$907	**$1,237**
Dec	2,120	12.5	$273	$195	$467		474.5	$1,565	**$2,032**
Jan 2014	2,407	12.5	$293	$269	$562		55.0	$179	**$742**
Feb	2,382	13.5	$303	$278	$580		95.2	$325	**$906**
Mar	2,083	12.0	$268	$180	$447		126.0	$398	**$845**
Apr 2014	1,822	8.5	$214	$132	$346		170.0	$520	**$866**
Annual (Units)	19,161		$2,421	$1,640	$4,061	947	1,240	$4,296	**$8,358**
Heating Season (Units)	11,433				$2,559	947	807	$2,977	**$5,536**
Annual ($/Unit)			$0.13	$0.09	$0.21			$3.47	
Heating Season ($/Unit)					$0.22			$3.69	
	Electricity kBtu					**Waste Oil kBtu**	**Oil kBtu**	**Energy Use Totals (kBtu)**	
Annual (kBtu)	65,377					118,413	171,974	355,764	**Energy $ Totals**
Heating Season (kBtu)	39,009					118,413	111,973	269,394	
								Totals (kBtu/sf)	**($/sf)**
Annual (kBtu/sf)	15.2					27.6	40.1	**83.0**	**$1.95**
Heating Season (kBtu/sf)	9.1					27.6	26.1	**62.8**	**$1.29**
Building Name	**Fire Station**							**Heated Square Footage**	**4,288**

HEAT BALANCE INFORMATION

BASELINE: Temperature & Schedule Information

Building Name: Fire Station

Total Heating Days	212	Floor SF	
Outdoor Winter Temperature	35	4,288	

	Wing name	Occupied Temp.	Unoccupied Temp. Night	Unoccupied Temp. Off days	Htg System Occ. Hrs per day *	Schedule	Occ Level Heating Days
1	Garage Bays +	58	58	58	8	5 days per week	151
2	Office & Mtng. Room	66	60	58	8	5 days per week	151

BASELINE: HEAT BALANCE

GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-213.2
INFILTRATION LOSSES	-71.4
VENTILATION LOSSES	0.0
SOLAR GAIN	16.3
OCCUPANT GAIN	0.6
ELECTRICAL GAIN	37.1
NET HEATING DEMAND	-230.6

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
230.6	290.4	79%

HEAT BALANCE CONTINUED

BASELINE: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Garage Bays +	1,601	8	151	23	44	
		1,601	16	151	23	89	
		1,601	24	61	23	54	187.3
2	Office & Mtng. Room	197	8	151	31	7	
		197	16	151	25	12	
		197	24	61	23	7	25.8
	Total UA	1,797			Conduction Total		213.2

BASELINE: INFILTRATION LOSSES

0.4

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Garage Bays +	51,277	0.60	16	151	0.018	23	30.8	
		51,277	0.60	24	61	0.018	23	18.6	
	Occ.	51,277	0.60	8	151	0.018	23	15.4	64.8
2	Office & Mtng. Room	6,974	0.40	16	151	0.018	25	3.0	
		6,974	0.40	24	61	0.018	23	1.7	
	Occ.	6,974	0.40	8	151	0.018	31	1.9	6.6
							Infiltration Total		71.4

HEATING SYSTEM CONTROL MEASURE

Summary of Energy Savings					
ECM 1	**Heating System Controls**				
	Baseline	**After ECM 1**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	230.6	223.9	6.71	2.9%	
Marginal System Efficiency	79%	79%			
Fuel Energy Usage (MMBtu/yr)	290.4	281.9			
Energy Savings	**% Reduction**	**Fuel Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
#2 Fuel Oil	2.9%	1,240	36	$3.47	$125
				Total Savings	**$125**

Cost	**Savings**	**Payback (yr)**
$1,863	**$125**	**14.9**

	% Reduction	**Fuel Use**	**Gallons Saved**
Waste Oil	2.9%	947	28

Note: Though savings of waste oil does not reduce cost, it reduces GHG emissions.
Payback would be much shorter if waste oil were purchased oil. 8.9 Equivalent Payback

Note:
Thermostat cost estimates were developed by BEA based in part upon figures from Sandri Energy, Greenfield, MA.

Heating System Control Improvement Costs		
		Cost ($)
Two (2) WiFi Compatible Programmable Thermostat	$	1,000
Installation & Setup	$	540
Subtotal	$	1,540
Contingency	$	154
Subtotal	$	1,694
Advisory & Contractor Oversight	$	169
Measure Total	***$***	***1,863***

GREENHOUSE GAS INFORMATION

Greenhouse Gas (GHG) Impact

Baseline Fuel Usage	Natural Gas	Oil	Waste Oil	Electricity	MT eCO2
Space Heating & Domestic Hot Water		1,240	947		23

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures Natural Gas (therm / yr)	Oil (gal / yr)	Waste Oil (gal / yr)	Electricity (kWh / yr)	GHG Emmissions (MT eCO2)	GHG Savings (MT eCO2)	Savings As % of Baseline
ECM 1	Heating System Controls		1,204	920		22	1	3%
						Totals:	*1*	*3%*

GHG Emmissions		
10.3	MT eCO2 / 1,000	gallons of #2 Fuel Oil
5.3	MT eCO2 / 1,000	gallons of Propane (LPG)
10.3	MT eCO2 / 1,000	gallons of Waste Oil
333.7	MT eCO2 / 1,000,000	kWh of electricity

per Clean Air Cool Planet Campus Carbon Calculator (2013 value)