BALES ENERGY ASSOCIATES

Date: April 22, 2014

DRAFT REVISION INCLUDING HEAT PUMP ANALYSIS

ENERGY STUDY
FOR
SLATE LIBRARY

332 Main Road
Gill, MA 01354

Completed By:

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Consulting Energy Engineer:
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Introduction

Bales Energy Associates, an energy efficiency engineering firm, was contracted to provide an ASHRAE Level 2 energy audit for the Slate Library located at 332 Main Road in Gill, Massachusetts.

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 the building's energy related systems.

Subsequent to the completion of this report and at the request of the Gill Energy Committee, Bales Energy Associates agreed to work in conjunction with Richard Baker, an IGSHPA certified heat pump specialist, to provide a preliminary evaluation of ground and air-source heat pump to this building. Cost estimates were provided by Mr. Baker and at the time of the provision of this draft study have not been independently evaluated by Bales Energy Associates. Results of these added heat pump analyses are included in the appendices.

Executive Summary

Energy Conservation Opportunities Being Evaluated

Bales Energy Associates was pleased to provide this Energy Study for the Slate Library.

It is noted that, if the roof and walls of the building can be insulated, there is an opportunity to potentially bring the upper balcony of the library back into use and to enhance the beauty and utility of the library.

Bales Energy Associates' study provides the costs and energy and dollar savings for a number of potential improvements. It will be up to the Town, the library committee, and the historic commission to determine which of the measures evaluated would be acceptable changes to the building. Bales Energy Associates will be happy to participate as a technical resource in a meeting to discuss the options.

Bales Energy Associates has approached the Slate Library in terms of the whole system. Improvements in various systems have interactive impacts with other systems. Key conclusions are the following:

1. **Enclosure Improvements** can substantially reduce the building's heat loss characteristics. Recommendations include:
    a. **Insulate the small attic area at the peak of the building to an R-value of R60.** Add sufficient cellulose insulation to achieve the desired attic floor assembly R-value. Air seal bypasses and penetrations in the attic.
    b. **Consider insulating the inside of the concrete block walls, and if the upper loft area of the library is to be re-opened to use, insulate the angled portions of the ceiling** (now above the existing drop ceiling) **with two inches of foam insulation (R14 total).**
    c. As part of this installation, the existing tin on the walls will be removed and two inch furring strips will be installed to allow the installation of sheetrock over the foam. (Depending upon the preferences of the Town, the tin may be left removed or re-installed after the walls have been insulated.)

d. Extend the proposed wall insulation to include the basement walls.
e. **A possible alternative would be to insulate the outside of the building with foam insulation and clad with clapboards, hardy plank, or other cladding material**. This would actually have better insulating and moisture management characteristics. **However, the consultant was led to believe that historical consideration with regard to the library might make an exterior insulation approach unacceptable.**
f. For long-term capital improvement, consider replacing the building's windows and framing to renew these important architectural features of the building. This will also reduce air leakage and conduction heat losses and improve occupant comfort**.**

2. Heating Systems Observations and Recommendations

a. Accomplishing the described envelope improvements will substantially reduce the peak heating load and the annual energy use for heating the building.
b. Option 1: Replace the existing oil-fired atmospheric furnace with a sealed combustion, propane-fired, condensing furnace. Install a town-owned propane storage tank.
c. If the furnace is to continue to be used and if the basement area is to be used for storage and not as a regularly occupied space, insulate heating system ductwork in the basement. This will reduce heat losses to the basement.
d. Install an improved microprocessor-based temperature control and temperature sensors. Install a new programmable microprocessor to provide scheduling of occupied and unoccupied periods.
e. **Option 2: Installation of a In-Duct Split System Air-to-Air VRF Heat Pump. A revised measure for the air-source heat pump option has been provided in this report.**
f. Option 3: Replace Existing System to Water-to-Water Ground-Source Heat Pump System and an in duct transfer coil.

The revised added Heat Pump options are included in the appendices.

3. Domestic Hot Water System Observations and Recommendations

Observations:

a. Domestic hot water use is very limited in the building; there is one lavatory sink in the basement.
b. The existing 30 gallon electric water heater is oversized to current needs.

Recommendations:

To reduce stand-by heat losses, **install a 2.5-gallon electric mini-tank adjacent to the sink in the basement lavatory.**

4. **Basement Moisture Observations and Considerations**

a. The basement of the Slate Library accumulates water in the center of the basement floor. To maintain healthy conditions for occupants and to render the basement space more useful as storage, eliminating this basement dampness issue should be accomplished.

Background:

Until the leaky covered entrance for the exterior basement door was removed and replaced with a new watertight bulkhead door, water leaked into the below grade door entry way and seeped under door. It is the consultant's understanding that with the new bulkhead door in place, such seepage no longer occurs under the door.

Water staining was also noted around the basement window nearest the basement exterior door. It is the consultant's belief during heavy rains water from the yard behind the building collects next to the basement window and seeps into the basement and then pools at the low spot in the middle of the basement floor.

Remediation Possibilities

Resolving this basement moisture issues is well beyond the scope of the current project. However, the consultant provides the following observations and thoughts for the Town's consideration.

By making limited changes to the landscape behind the building, it may be possible to eliminate this seeping effect. Provision of a proper recessed and graveled bottomed cellar window feature may help remediate this situation. Making minor grading changes so that the yard slopes away from the building (rather than toward the building as it does now. A small overhang located immediately above the basement windows could also aid in directing water or snow away from the area next to the basement window is also an option.

If employing of these simple, low-cost approaches is successful, then more expensive remediation approaches may not be necessary.

If these approaches are not effective in eliminating the pooling of water at the center of the basement floor, then sub-surface water may be contributing to the moisture problem. Resolving such issues would require added professional evaluation.

The costs, savings, and economic payback for these energy conservation measures will be presented in an Executive Summary Chart. The values shown in the Executive Summary Table will represent the savings with measures taken in the order of economic feasibility shown.

The calculations supporting each measure will be included in the appendices. Information related to the added heat pump measures is included in the appendices.

Executive Summary Chart

							Oil	Propane						
							$2.98	$2.15						
							$/Gallon	$/Gallon						
ECM #	Energy Conservation Measures	Cost	Incremental Cost ($)	Available Utility Rebates ($)	Total Cost after Rebate ($)	Incremental Cost after Rebate ($)	Oil Savings (Gallons/yr)	Propane Savings (Gallons/yr)	Annual Savings ($/yr)	Total Payback (yrs)	Incremental Payback (yrs)	Total Payback Payback after Rebates (yrs)	Incremental Payback after Rebates (yrs)	Life Years
ECM1	Install Propane-Fired Furnace	$13,490	$4,990	0	$13,490	$4,990	545	-617	$296	45.6	16.9	45.6	16.9	20+
ECM2	Option A: Insulate & Air-Seal the Top Attic	$1,256	$1,256	0	$1,256	$1,256		20	$42	29.9	29.9	29.9	29.9	30+
ECM2	Option B: Insulate Top Attic & Sloping Roof	$6,794	$6,794	0	$6,794	$6,794		129	$277	24.5	24.5	24.5	24.5	30+
ECM2	Option C: Insulate Walls, Top Attic & Sloping Roof	$12,187	$12,187	0	$12,187	$12,187		167	$359	33.9	33.9	33.9	33.9	30+
	Totals for ECM1 & ECM2A	$14,746	$6,246	$0	$14,746	$6,246	545	-597	$338	43.7	18.5	43.7	18.5	
	Totals for ECM1 & ECM2B	$20,284	$11,784	$0	$20,284	$11,784	545	-488	$573	35.4	20.6	35.4	20.6	
	Totals for ECM1 & ECM2C	$25,677	$17,177	$0	$25,677	$17,177	545	-450	$655	39.2	26.2	39.2	26.2	

Existing Conditions

Facility Description

The Slate Library is a small concrete block, sloped-roofed building located at 325 Main Road Gill, Massachusetts. Currently, the first floor space is the space actively used for the library's stacks and for library activities. It is mostly an open plan space with a large room and a connected children's room. There are no doors between the two rooms. There is a door separating the small room at the foot of the balcony stairs.

The building was originally designed with an attractive high-arched ceiling with exposed wooden beams and a usable balcony area. This arched ceiling is no longer visible because a drop ceiling was installed at approximately the same level as the ceiling under the balcony. The balcony area is now used for storage.

The basement was originally designed to be a conditioned space but is not much used, even for storage, due to issues of water collecting on the concrete basement floor. The only lavatory in the building is located in the southeast corner of the basement.

The library is open on Tuesdays 2-6 pm, Wednesdays 3-7 pm, Thursdays 2-8 pm, and Saturdays 10 am - 2 pm. It is also open on Fridays for a 10 am story hour. The space is also used occasionally for town-related meetings and for special events.

Utility Energy Use

Utility data was collected and is tabulated below. Western Massachusetts Electric Company provides electricity. For heating, the Slate Library uses #2 fuel oil. (Note: WMECO and its parent company Northeast Utilities, recently merged with NSTAR. As a result, changes in procedures and personnel in charge of related utility programs are in transition.)

Jul 2012-June 2013					
Building Name	**Slate Library**				
Owner	**Town Of Gill, MA**				
Account #					
	Electricity	Electricity	Oil	Oil	**Energy $**
Month	KWH	Total $	Gallons	$	**Totals**
July 1, 2012	68	$37			**$37**
Aug	54	$35			**$35**
Sept	90	$56	42.9	$128	**$184**
Oct	25	$15		$0	**$15**
Nov	80	$38		$0	**$38**
Dec	238	$70	104.1	$310	**$380**
January 1, 2013	70	$20	210.0	$625	**$645**
Feb	184	$49	76.3	$227	**$276**
Mar	125	$43		$0	**$43**
Apr	115	$42	111.3	$331	**$373**
May	133	$60			**$60**
Jun	45	$18			**$18**
Annual (Units)	1,227	$482	544.6	$1,622	**$2,104**
Heating Season (Units)	837	$275	544.6	$1,494	**$1,770**
Annual ($/Unit)		$0.393		$2.978	
Heating Season ($/Unit)		$0.329		$2.978	
	Electricity		Oil	**Energy Use**	
	MBtu		MBtu	**Totals (Mbtu)**	
Annual (Mbtu)	4,187		75,536.0	79,723	**Energy $**
Heating Season (Mbtu)	2,856		75,536.0	78,392	**Totals**
$/Energy Unit				**Totals (Mbtu/sf)**	**($/sf)**
Annual (Mbtu/sf)	1.4		25.2	**26.6**	**$0.70**
Heating Season (Mbtu/sf)	1.0		25.2	**26.2**	**$0.59**
Htng Season $/Energy Unit					
Building Name	**Slate Library**			Heated SF	**2,994**

Prescriptive and custom utility incentives may be available for some of the measures described. When the report's contents are accepted by the client, the report may be presented to the utilities for review and determination of levels of custom incentives the utilities will offer, if any. Western Massachusetts Electric Company contacts are: Lynn Ditullio (ditullb@nu.com) and Robert Dvorchik (dvorcrs@nu.com).

Heating, Ventilating & Air Conditioning Systems

Hot Air Furnace

The building is served by an atmospheric, oil-fired, non-condensing hot air furnace (Williamson WLBO-105) installed in 1999. This single-firing rate boiler has an output heating capacity of 105,000 Btu/hr. The boiler has a measured combustion efficiency of 82%.

The design heat load for the building is approximately 54,000 Btu/hr.

Bales Energy Associates recommends replacement of the existing oil-fired, atmospheric furnace with a sealed combustion, propane-fired, condensing furnace and the installation of a town-owned propane storage tank.

Given the heat load, the limited use of the library, the level of use of the building, and other factors, installation of an air-source heat pump does not seem justified in terms of energy cost savings.

In an update to this report, the Energy Committee contracted for added evaluation of air and ground-source measures in this report. They are included in the Appendix.

Heating Distribution Systems

The building is a ducted, forced hot air heating system.

Domestic Hot Water Heating Systems

Hot water is provided by a small well-insulated electric hot water heater located in lavatory in the basement. Water usage is minimal in the building as water uses are limited to a lavatory sink.

Lighting Systems

Most spaces in the building are lighted with four foot fluorescent fixtures equipped with 32 watt, T-8 lamps and electronic ballasts.

Building Enclosure

The finished basement, first, and second floors of the Slate Library comprise approximately 2,210 heated square feet of floor area. The building includes a fireplace which is no longer used. Occupants should assure that the fireplace damper is maintained in the closed position in the heating season. By preventing heated room air from being drawn out of the heated space and up the chimney by thermal buoyancy effects, infiltration of cold outside replacement air into the heated space will be reduced.

Roof and Attic

The Slate Library has a small inaccessible attic.

The sloped sections of the second story ceiling and the attic area above the center flat section of ceiling are not insulated. Ceilings are covered with decorative tin.

Recommendation for the Attic and Sloped Ceiling Areas:

Bales Energy Associates recommends insulating the attic with cellulose to an R-value of R60.

Bales Energy Associates recommends insulating the sloped section of the ceiling with 3 inches of foam insulation.

(Note: The tin will need to be removed for the insulating of the sloped sections. Given the unique nature and potential historical considerations of the tin ceiling, costs related to tin removal and handling are not included in this report.)

First Floor Ceiling:

Currently there is a t-bar drop ceiling installed to create a lower ceiling for the main reception area. Fiberglass batt insulation has been installed on top of the drop ceiling in an attempt to reduce heat losses to the less heated second floor area.

As already noted in the facility description section, the main circulation room of the library was designed with a high-ceiling with attractive wooden arches. The second floor was originally a balcony overlooking the main reception area. This balcony is located above the current children's room, the entry way and the side room.

Library staff and library committee members have indicated an interest in the potential restoration of the library circulation room to its original high-ceiling configuration. Insulating the upper ceilings will help mitigate energy use impacts of such a restoration.

To further reduce building energy losses, insulation of the first and second floor concrete block walls of the building with 2 inches of foam insulation on the inside of the building has also been evaluated in this report. (At the request of the library committee, exterior insulation was not considered due to the historical nature of the building exterior.)

Installation of rim joist insulation in the basement was included in the added costs for wall insulation. Air sealing of the rim joist was also included.

It is assumed that the foam will be covered with sheetrock after insulation. Studs for mounting of the sheetrock will also need to be installed. (Note: Rough costs were carried for the carpentry required for the work. These costs will vary depending upon the exact interior design preferences of the Town. Tin removal and/or reinstallation costs were not included.)

The enclosure improvements were presented as three options:

A. **Insulation and air sealing of flat attic only**
B. **Insulation of sloped ceiling and flat attic**
C. **Insulation of walls, rim joist, sloped ceiling and flat attic**

APPENDICES

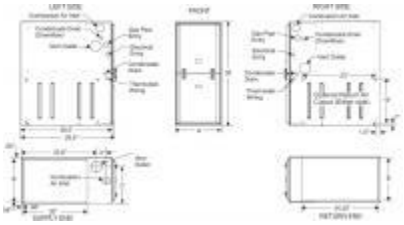
EXISTING FURNACE

Williamson Furnace of Same Type as Existing Furnace at Slate Library

PROPANE-FIRED CONDENSING FURNACE

York Hot Air Furnace

Gas Furnace TM9V LX Series TM9V060 B12MP11



Details for LX Series TM9V060 B12MP11:

96% 2 Stage Variable Speed Multi-Position Gas Furnace

These compact units employ induced combustion, reliable hot surface ignition and high heat transfer aluminized tubular heat exchangers. The units are factory shipped for installation in upflow or horizontal applications and may be converted for downflow applications.

These furnaces are designed for residential installation in a basement, closet, alcove, attic, recreation room or garage and are also ideal for commercial applications. All units are factory assembled, wired and tested to assure safe dependable and economical installation and operation.

These units are Category IV listed and may be vented either through side wall or roof applications using approved plastic combustion air and venr piping.

Technical details for LX Series TM9V060 B12MP11:

Low Fire Input	39,000 BH
High Fire Input	60,000 BH
Low Fire Output	37,000
High Fire Output	58,000 BH
Efficiency (AFUE)	96 %
Air Temp. Rise Max Input	35-65
Air Temp. Rise Min Input	35-65
Total Unit	9 AMPS
Blower	0.5 HP
Blower Wheel Size	11 x 8
Max Over-Current Protect	15
Cabinet Size	B
Cabinet Dimensions	17.5 X 16.375 X 13.25 INCHES

Tognarelli HEATING & COOLING
85 Pierce Street - Greenfield, MA 01301

PROPOSAL

NAME / ADDRESS
Bales EnergyAssociates Bart Bales PE,MSME 50 Miles St Greenfied, MA 01301

DATE
10/14/2013

DESCRIPTION	QTY	TOTAL
Job Location: Gill Library, Gill	1	18,480.00
Price to install one Mitsubishi (Model#: PUZ-HA36NHA) twinned system with two 18,000 BTU heads. Price is based on prevailing wage and includes all parts and labor.		
Price to install one York (Model#: TM9V060) high efficient two stage variable speed propane furnace. Price is based on prevailing wage and includes all parts and labor.	1	11,390.00
Thank you for your time.	**TOTAL** *includes sales tax*	$29,870.00

INSULATION QUOTE INFORMATION

Slate Library

	Location	Measure	Depth	R-Value	# / SF	Cost
1	Walls	Spray Foam Closed Cell	2	14	1,396	$3,490
2	Attic Slope	Spray Foam Closed Cell	3	21	868	$3,038
3	Attic Floor	Cellulose Open Blow	11	41	388	$620
4	Attic Floor	Cellulose OB to R60 Adder	6	22	388	$136
5	Attic	Air Sealing	0	N/A	6	$450
6	Basement Rim & Band	Spray Foam Closed Cell	2	14	124	$403
	Total					$8,137

* This assumes that the tin is removed and the assemblies are framed-out to accommodate space for insulation. Ideally thermal bridging would be mitigated by leaving a space between the new framing and the old wall.

None of this pricing accounts for permitting costs. Large structures may also require a construction control affidavit from an Architect or Engineer.

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CALCULATIONS

Option#1: Propane-Fired Condensing Furnace

Space Heating Savings with Propane-Fired Condensing Hot Air Furnace

Slate Library
Gill, MA

Oil Rate ($/gallon)					Propane $/gallon	
$2.98	Existing Condition:			New Condition:	$2.15	
Equipment Type	Space Heating Furnace			Space Heating Furnace		
Boiler #	1			1		
Make	Williamson			York		
Model	WLRO-60			TM9VO60		
Type	Non-Condensing			Condensing		
Heating Medium	Hot Air			Hot Air		
Control Mode				Two-Stage, Variable Speed		
Maximum Output Mbtu/Hr	105			60		
Steady State Eff	83%			92%		
Input Mbtu/Hr	127			65		
Seasonal Eff	78%		AFUE	96%		
Percentage of Load	100%			100%		
Installed System Costs				Condensing Furnace		
Boiler	$8,500	Propane-Fired Condensing Furnace		$11,390		
		Propane tank		$2,100		
Totals	$8,500			$13,490		

Annual Building Operating Load (MMbtu/year)	Summary of Existing Building-Related Heat Loads	Existing Oil Heating Usage Gallons	New Propane Heating Usage Gallons	Fuel Cost $	Peak Space Heating Load (Mbtu/hr)	Provide (#) 1 Boilers @ 100% of design Load
58,918	Existing Oil Use	545		$1,622	54	
58,918	New Propane Use		617	$1,326		

Fuel Energy Before	75,536		
Fuel Energy After	61,373		
Fuel Energy saved	14,163	Savings $	$296

Assuming Existing Boiler
Payback Calculation:

	Cost	Savings	Payback
Full Equipment Cost Basis:	$13,490	$296	45.6
Incremental Equipment Cost Basis:	$4,990	$296	16.9

Option#2:
Installation of Ducted Split System Air-to-Air VRF Heat Pump (Revised measure)

Space Heating Savings with Ducted Split Air-Source Heat Pump System						
		Slate Library Gill, MA			Electricity $/KWH	
Oil Rate ($/gallon)						
$2.98	Existing Condition:			New Condition:	$0.144	
Equipment Type	Space Heating Boiler			Air-Source Heat Pump		
Boiler #	1			1		
Make	Williamson			Daikin Skyair		
Model	WLRO-60	Supplemental Electric Coil (5KW)		Peak/Back-up		
Type	Non-Condensing			HSPF:8.8		
Heating Medium	Hot Air			Air-to Air		
Control Mode			Rating (tons)	3.9		
ximum Output Kbtu/	105			47.0		
Steady State Eff	83%		Mean	230%		
Input Mbtu/Hr	127			20		
Seasonal Eff	78%			230%		
Percentage of Load	100%			100%		
stalled System Costs		High-Performance Heating System				
Boiler	$8,500	Nine (9) Split-System Air-Source VRF Heat Pumps		$15,000		
		Integrating Controls		$1,270		
		Subtotal		$16,270		
		Contingency		$1,627		
		Subtotal		$17,897		
		System Configuration Contractor Oversight		$1,790		
Totals	$8,500	Total		$19,687		

Annual Building Operating Load (MMbtu/year)	Summary of Existing Building-Related Heat Loads	Existing Oil Heating Usage Gallons	New Electricity Heating Usage KWH	Fuel Cost $	Peak Space Heating Load (Mbtu/hr)	Provide (#) 1 Boilers @ 100% of design Load
58,918	Existing Oil Use	545		$1,623	47	47
58,918	New Electricity Use		7,506	$1,081		

KWH

Fuel Energy Before	58,918		
Fuel Energy After	25,617		
uel Energy saved	33,302	Savings $	$542

Payback Calculation:

	Cost	Savings	Payback	Incentive per Ton
Full Equipment Cost Basis:	$19,687	$542	36.3	
Renewable Thermal Incentive (CEC/DOER)				
Utility Incentive (Mass-Save)	-$313			$80
Full Equipment Cost Basis after Incentive:	$19,373	$542	35.7	
Incremental Equipment Cost Basis:	$11,187	$542	20.6	
Renewable Thermal Incentive (CEC/DOER)	$0			
Utility Incentive (Mass-Save)	-$313			
Incremental Equipment Cost Basis:	$10,873	$542	20.1	

Air Source Heat Pump Data for Slate Library
From Rich Baker ASHP Preliminary Report

Project: Gill Slate Library HVAC upgrades
Prepared: April 1, 2014
Prepared By: Richard Baker, IGSHPA 24526-0209

RE: ASHP Preliminary Report Gill Slate Library

System Loads

System loads or peak loads are calculated based on a variety of details for an individual facility, assumed occupancy levels, the number of appliances operating, the number of doors & windows, and the tightness of the construction all contribute to the amount of energy required to maintain the thermostat set points given the historical extreme weather conditions in your area.

1 kBtu/hr = 1,000 Btu/hr

Zone	Total Heating Load	Total Cooling Load	SHF
Zone 1	54.0 kBtu/hr		0.900
Total	54.0 kBtu/hr		

1. Peak Loads used here as provided by: Bart Bales, PE
2. This report is primarily concerned with heating load and associated operational costs therefore cooling load is not being considered at this point.

Equipment Schedule

Based on the provided loads and space configuration considerations, the preliminary ASHP equipment schedule for this system is as follows:

Zone	Equipment	QTY	Heat Capacity KBtu/hr (Low Stage)	Heat Capacity kBtu/hr (High Stage)	Water Flow (GPM)	Air Flow (CFM)
Entire Building	Daikin SkyAir	1		47,000		1377/1165/988

1. The installation of a 5kw duct mounted electric auxiliary heater is recommended to supplement this system for peak load requirements.

Rated System Efficiencies:
HSPF: 8.8
COP: 3.2 @ 43 FWB/47 FDB

Anticipated Cost to Install: $ 15,000

Option 3: Replace Existing System to Water-to-Water Ground-Source Heat Pump System and an In-Duct Transfer Coil

Space Heating Savings with Water-toWater Ground-Source Heat Pump System						
		Slate Library Gill, MA			Electricity $/KWH	
Oil Rate ($/gallon)						
$2.98	Existing Condition:			New Condition:	$0.144	
Equipment Type	Space Heating Furnace			Ground-Source Heat Pump		
Furnace #	1			1		
Make	Williamson		In-Duct	Hydron		
Model	WLRO-60		Heat Pumps (1)	HWT026		
Type	Non-Condensing		Supplemental Electric Coil (5KW)	Peak/Back-up		
Heating Medium	Hot Air			Water-to-Water		
Control Mode			Rating (tons)	4.1		
ximum Output Mbtu/	105			48.7	% Includes effect of	
Steady State Eff	83%			352%	(90% by HP; 10% electric at peak)	
Input Mbtu/Hr	127			14		
Seasonal Eff	78%			352%		
Percentage of Load	100%			100%	(90% by HP; 10% electric at peak)	
stalled System Costs		High-Performance Heating System				
Furnace	$8,500	One (1) Water-to-Water Heat Pumps				
		Serving Ten (10) Fan-Coil Units				
		Ground-Coupling: Borefield with				
		Two 333 Foot Boreholes		$35,500		
		Integrating Controls		$1,270		
		Subtotal		$36,770		
		Contingency		$3,677		
		Subtotal		$40,447		
		System Configuration Contractor Oversight		$4,045		
Totals	$8,500	Total		$44,492		

Annual Building Operating Load (MMbtu/year)	Summary of Existing Building-Related Heat Loads	Existing Oil Heating Usage Gallons	New Electricity Heating Usage KWH	Fuel Cost $	Peak Space Heating Load (Mbtu/hr)	Provide (#) 1 Heat pumps @ 90% of design Load
58,918	Existing Oil Use	545		$1,623	49	44
58,918	New Electricity Use		4,904	$706		

KWH

Fuel Energy Before	58,918
Fuel Energy After	16,738
uel Energy saved	42,180

Savings $ $917

58,918

	Cost	Savings	Payback	Incentive per Ton
Full Equipment Cost Basis:	$44,492	$917	48.5	
Renewable Thermal Incentive (CEC/DOER)	-$8,117			$2,000
Utility Incentive (Mass-Save)	$0			
Full Equipment Cost Basis after Incentive:	$36,375	$917	39.7	
Incremental Equipment Cost Basis:	$35,992	$917	39.3	
Renewable Thermal Incentive (CEC/DOER)	-$8,117			
Utility Incentive (Mass-Save)	$0			
Incremental Equipment Cost Basis:	$27,875	$917	30.4	

Ground-Source Heat Pump Data for Slate Library
From Baker GSHP Preliminary Report

Project: Gill Slate Library HVAC upgrades
Prepared: March 13, 2014
Prepared By: Richard Baker, IGSHPA 24526-0209

RE: GSHP Preliminary Report Gill Slate Library

System Loads

System loads or peak loads are calculated based on a variety of details for an individual facility, assumed occupancy levels, the number of appliances operating, the number of doors & windows, and the tightness of the construction all contribute to the amount of energy required to maintain the thermostat set points given the historical extreme weather conditions in your area.

1 kBtu/hr = 1,000 Btu/hr

Zone	Total Heating Load	Total Cooling Load	SHF
Zone 1	54.0 kBtu/hr		0.900
Total	54.0 kBtu/hr		

3. Peak Loads used here as provided by: Bart Bales, PE
4. This report is primarily concerned with heating load and associated operational costs therefore cooling load is not being considered at this point.

Equipment Schedule

Based on the provided loads and space configuration considerations, the preliminary GSHP equipment schedule for this system is as follows:

Zone	Equipment	QTY	Heat Capacity KBtu/hr (Low Stage)	Heat Capacity kBtu/hr (High Stage)	Water Flow (GPM)	Air Flow (CFM)
Entire Building	Hydron Module – HXT060	1	38.80	48.70	15.0	2,150

1. All capacities shown are total
2. For water to water equipment, source and load water flows are assumed equal.
3. Capacities are adjusted for 30F EWT and Glycol protection to 15F with EAT 68F
4. When equipment allows continuous fan operation is recommended
5. Avoid using dramatic night time set back
6. Installed GSHP COP 3.55 High Capacity and 3.98 Low Capacity

GSHP Selection

Manufacturer: **Hydron Module**
Model: **HXT060**

Heat Pump Type: **Water to Water** Capacity: **Dual**

Installation Cost	$35,500.	

Ground Heat Exchange Summary

Grout is used inside of all bores in order to protect the deep earth environment from surface contaminants and to provide a more effective contact surface with GHEX piping that optimizes heat transfer between the fluid pumped through your GSHP and the earth. Deep Earth (below 20ft) temperature is a function of the average annual air temperature in your region and remains relatively constant regardless of season.

Deep Earth Temp (Tg) 52.0 F

Formation T.C.	1.30 Btu/hr ft F
Grout T.C.	1.00 Btu/hr ft F
EWTmin	30.0F
EWTmax	90.0F
Bore Diameter	6.00 in
Pipe Diameter	1.25 in
Bores in Series	1
Layout Rows	1
Bores per Row	2
Number of Bores	2
Bore Spacing	25.0 ft on center
Bore Depth	301 ft
Adj. Bore Depth*	333 ft
System Run Fraction	0.613

Adj. Bore Depth is the adjusted bore depth. This is the depth of bore that should be used to accommodate unbalanced ground loads over time. A pre-construction test bore is recommended.

Grouting the bore annulus: Each vertical bore is to be grouted from the bottom to the top. Grout field mix T.C. testing is recommended. Grout Recommendation: TGLite by GeoPro Inc.

GHEX Piping:

Vertical Bore: 1.25” HDPE SDR-11 with factory u-bend

Horizontal Piping:

From Bore to Building all pipe should be a minimum of 4’ below grade.
Supply lines should be below Return lines.
2” foam board insulation should separate supply and return lines when feasible.
2” foam board insulation should be above return lines when feasible.
Horizontal piping should be in backfill free from material that may be a hazard to the pipe.

GHEX Manifold:

Vertical bore loopfield will be (2) individual closed loop circuits bringing in a total of (2) 1.25” supply and (2) 1.25” return lines. Interior piping: install full port valves on each supply and each return to a common supply and common return header. Install fill and drain ports followed by full port valves on header. Connect supply and return to pumping station.

Note: Mechanical or ‘Stab’ fittings are not recommended for any portion of exterior below grade piping. All exterior below grade pipe connections are to be by fusion of HDPE pipe and HDPE fittings.

Wall penetrations to be sealed with 'link seal' style fittings inside pvc sleeve. Sleeve sealed with either silicone, hydrolic cement or similar.

Recommended freeze protection – 22% to 15 F with Propylene Glycol

System Sequencing

1. GSHP thermostat calls for conditioning
2. GHEX circulator pump responds causing flow in GHEX
3. GSHP provides desired conditioning

It is recommended that where GSHP equipment allows that the fan be set to on at all times. This maintains desired air circulation blending conditioned air more evenly throughout the conditioned space. Doing this will reduce the circumstance of hot spot/cold spot improving occupant comfort and reducing overall energy consumption.

Equipment Efficiencies

Note: GSHP efficiencies shown below are system wide averages which include pumping and applicable resistance energy. ASHP efficiencies have been adjusted from manufacturer's stated HSPF to more closely reflect installed operation in your region.

GSHP (COP avg) 3.52

INSULATION SAVINGS CALCULATIONS

ECM#2A — Summary of Energy Savings - ATTIC INSULATION

	Baseline Heat Load	After ECM #2A	Savings 10E6 Btu/yr	% Reduction
Fuel Energy Usage (MMBtu/yr)	58.59	56.74	1.86	3.2%
New Furnace System efficiency	96%	96%		
Fuel Energy Usage (MMBtu/yr)	61	59		

Energy Savings	% Reduction	Propane Use after ECM1a	Gallons Saved	$/Unit	$ Saved
	3.2%	617	20	$2.150	$42
				Total Savings ($)	$42

		Measure	Cost $	Savings $	Payback Years
Attic Insulation& Air Sealing	$1,256	ECM2A	$1,256	$42	29.9

Note:
Cost estimates were developed by BEA based upon quotes by EnergiaUSA

ECM#2B — Energy Savings -SLOPED CEILING & ATTIC INSULATION

	After ECM #1	After ECM #2B	Savings 10E6 Btu/yr	% Reduction
Fuel Energy Usage (MMBtu/yr)	58.59	46.36	12.23	20.9%
New Furnace System efficiency	96%	96%		
Fuel Energy Usage (MMBtu/yr)	61	48		

Energy Savings	% Reduction	Propane Use after ECM1	Gallons Saved	$/Unit	$ Saved
	20.9%	617	129	$2.150	$277
				Total Savings ($)	$277

		Measure	Cost $	Savings $	Payback Years
Attic Insulation& Roof Slope & Air Sealing , including Installation of studs to support sheet rocking over new insulation	$6,794	ECM2B	$6,794	$277	24.5

Note1: Does not include removal of decorative tin or its reinstalltion
Note 2: Insulation cost estimates were developed by BEA based upon quotes by EnergiaUSA

ECM#2C Energy Savings: WALL, SLOPED CEILING & ATTIC INSULATION

	After ECM #2	After ECM #2C	Savings 10E6 Btu/yr	% Reduction
Fuel Energy Usage (MMBtu/yr)	58.59	42.73	15.87	27.1%
New Furnace System efficiency	96%	96%		
Fuel Energy Usage (MMBtu/yr)	61	45		

Energy Savings	% Reduction	Propane Use after ECM1	Gallons Saved	$/Unit	$ Saved
	27.1%	617	167	$2.150	$359
				Total Savings ($)	$359

		Measure	Cost $	Savings $	Payback Years
Air Sealing , including Installation of studs to sup sheet rocking over new insulation	$12,187	ECM2C	$12,187	$359	33.9

Note1: Does not include removal of decorative tin or its reinstallation nor removal, storage, or handling of existing books and bookshelves.

Note 2: Insulation cost estimates were developed by BEA based upon quotes by EnergiaUSA

HEAT BALANCE- EXISTING CONDITION

HEAT BALANCE		
GAINS AND LOSSES	BTU/HEATING SEASON*1E6	
CONDUCTION LOSSES	-74.7	
INFILTRATION LOSSES	-12.8	
VENTILATION LOSSES	0.0	
SOLAR GAIN	20.7	
OCCUPANT GAIN	5.5	
ELECTRICAL GAIN	2.7	
NET HEATING DEMAND	-58.6	

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
58.6	76	78%

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Basement	26	4	120	20	0	
		26	20	120	15	1	
		26	24	92	15	1	2.0
2	Main Library Area	366	4	120	35	6	
		366	20	120	27	24	
		366	24	92	20	16	46.0
3	Room at Base of Stairs	66	4	120	25	1	
		66	20	120	23	4	
		66	24	92	20	3	7.3
4	Loft Storage Area	174	4	120	25	2	
		174	20	120	23	10	
		174	24	92	20	8	19.4
	Total UA	**631**		**Conduction Total**			**74.7**

				INFILTRATION LOSSES					
			0.4						
#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Basement	6,054	0.35	20	120	0.018	15	1.4	
		6,054	0.35	24	92	0.018	15	1.3	
	Occ.	6,054	0.35	4	120	0.018	20	0.4	3.0
2	Main Library Area	6,541	0.40	20	120	0.018	27	3.1	
		6,541	0.40	24	92	0.018	20	2.1	
	Occ.	6,541	0.50	4	120	0.018	35	1.0	6.1
3	Room at Base of Stairs	935	0.35	20	120	0.018	23	0.3	
		935	0.35	24	92	0.018	20	0.3	
	Occ.	935	0.35	4	120	0.018	25	0.1	0.7
4	Loft Storage Area	4,325	0.35	20	120	0.018	23	1.5	
		4,325	0.35	24	92	0.018	20	1.2	
	Occ.	4,325	0.35	4	120	0.018	25	0.3	3.0
						Infiltration Total			12.8

HEAT LOSS COEFFICIENTS						
Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Basement**	Roof	0.059	0		0
		Walls		0		0
		Walls - Below Grade	0.021	868		18
		Doors	0.400	0		0
		Windows	0.550	0		0
		Slab/Floor	0.008	961		8
				Wing UA Total	**25.6**	
2	**Main Library Area**	Ceiling to Loft	0.033	961		22
		Walls	0.082	664		54
				0		0
		Doors	0.400	23		9
		Windows	0.550	210		116
		1st Floor to Basement	0.171	961		165
				Wing UA Total	**365.8**	
3	**Room at Base of Stairs**	Roof	0.033	961		32
		Walls	0.082	153		13
				0		0
		Doors	0.400	0		0
		Windows	0.550	39		21
		Slab/Floor	0.171			0
				Wing UA Total	**65.7**	
4	**Loft Storage Area**	Roof	0.059	372		22
		Walls Vertical	0.082	190		16
		Sloped Roof Area	0.145	868		126
		Doors	0.400	0		0
		Windows	0.550	20		11
		Slab/Floor	0.008			0
				Wing UA Total	**174.3**	
				Building Total UA:	**631.4**	

HEAT LOADS AFTER ECM2A
ATTIC INSULATION

HEAT LOADS AFTER ECM2A		
GAINS AND LOSSES	BTU/HEATING SEASON*1E6	
CONDUCTION LOSSES	-73.0	
INFILTRATION LOSSES	-12.7	
VENTILATION LOSSES	0.0	
SOLAR GAIN	20.7	
OCCUPANT GAIN	5.5	
ELECTRICAL GAIN	2.7	
NET HEATING DEMAND	-56.7	

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	26	4	120	20	0	
		26	20	120	15	1	
		26	24	92	15	1	2.0
2	**Main Library Area**	366	4	120	35	6	
		366	20	120	27	24	
		366	24	92	20	16	46.0
3	**Room at Base of Stairs**	66	4	120	25	1	
		66	20	120	23	4	
		66	24	92	20	3	7.3
4	**Loft Storage Area**	158	4	120	25	2	
		158	20	120	23	9	
		158	24	92	20	7	17.6
	Total UA	**615**		**Conduction Total**			**73.0**

INFILTRATION LOSSES

0.4

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	6,054	0.35	20	120	0.018	15	1.4	
		6,054	0.35	24	92	0.018	15	1.3	
	Occ.	6,054	0.35	4	120	0.018	20	0.4	3.0
2	**Main Library Area**	6,541	0.40	20	120	0.018	27	3.1	
		6,541	0.40	24	92	0.018	20	2.1	
	Occ.	6,541	0.50	4	120	0.018	35	1.0	6.1
3	**Room at Base of Stairs**	935	0.35	20	120	0.018	23	0.3	
		935	0.35	24	92	0.018	20	0.3	
	Occ.	935	0.35	4	120	0.018	25	0.1	0.7
4	**Loft Storage Area**	4,325	0.34	20	120	0.018	23	1.5	
		4,325	0.34	24	92	0.018	20	1.2	
	Occ.	4,325	0.34	4	120	0.018	25	0.3	2.9
						Infiltration Total			**12.7**

HEAT LOADS AFTER ECM2B
SLOPING CEILING & ATTIC INSULATION

HEAT LOAD AFTER ECM2B		
GAINS AND LOSSES	BTU/HEATING SEASON*1E6	
CONDUCTION LOSSES	-62.6	
INFILTRATION LOSSES	-12.7	
VENTILATION LOSSES	0.0	
SOLAR GAIN	20.7	
OCCUPANT GAIN	5.5	
ELECTRICAL GAIN	2.7	
NET HEATING DEMAND	-46.4	

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Basement	26	4	120	20	0	
		26	20	120	15	1	
		26	24	92	15	1	2.0
2	Main Library Area	366	4	120	35	6	
		366	20	120	27	24	
		366	24	92	20	16	46.0
3	Room at Base of Stairs	66	4	120	25	1	
		66	20	120	23	4	
		66	24	92	20	3	7.3
4	Loft Storage Area	65	4	120	25	1	
		65	20	120	23	4	
		65	24	92	20	3	7.3
	Total UA	522		Conduction Total			62.6

HEAT LOSS COEFFICIENTS						
Zone #	**Building Zone**		**U-Value (BTU/hr-sf-F)**	**Area (sf)**		**UA-Value (BTU/hr-F)**
1	**Basement**	Roof	0.059	0		0
		Walls		0		0
		Walls - Below Grade	0.021	868		18
		Doors	0.400	0		0
		Windows	0.550	0		0
		Slab/Floor	0.008	961		8
				Wing UA Total	**25.6**	
2	**Main Library Area**	Ceiling to Loft	0.033	961		22
		Walls	0.082	664		54
				0		0
		Doors	0.400	23		9
		Windows	0.550	210		116
		1st Floor to Basement	0.171	961		165
				Wing UA Total	**365.8**	
3	**Room at Base of Stairs**	Roof	0.033	961		32
		Walls	0.082	153		13
				0		0
		Doors	0.400	0		0
		Windows	0.550	39		21
		Slab/Floor	0.171			0
				Wing UA Total	**65.7**	
4	**Loft Storage Area**	Roof	0.016	372		6
		Walls Vertical	0.082	190		16
		Sloped Roof Area	0.038	868		33
		Doors	0.400	0		0
		Windows	0.550	20		11
		Slab/Floor	0.008			0
				Wing UA Total	**65.2**	
				Building Total UA:	**522.3**	

HEAT LOADS AFTER ECM2C
WALL, SLOPING CEILING & ATTIC INSULATION

HEAT LOAD AFTER ECM3C		
GAINS AND LOSSES	BTU/HEATING SEASON*1E6	
CONDUCTION LOSSES	-59.5	
INFILTRATION LOSSES	-12.4	
VENTILATION LOSSES	0.0	
SOLAR GAIN	20.7	
OCCUPANT GAIN	5.5	
ELECTRICAL GAIN	2.7	
NET HEATING DEMAND	-43.0	

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	26	4	120	20	0	
		26	20	120	15	1	
		26	24	92	15	1	2.0
2	**Main Library Area**	349	4	120	35	6	
		349	20	120	27	23	
		349	24	92	20	15	43.9
3	**Room at Base of Stairs**	62	4	120	25	1	
		62	20	120	23	3	
		62	24	92	20	3	6.9
4	**Loft Storage Area**	60	4	120	25	1	
		60	20	120	23	3	
		60	24	92	20	3	6.7
	Total UA	**496**		**Conduction Total**			**59.5**

HEAT LOSS COEFFICIENTS						
Zone #	**Building Zone**		**U-Value (BTU/hr-sf-F)**	**Area (sf)**		**UA-Value (BTU/hr-F)**
1	**Basement**	Roof	0.059	0		0
		Walls		0		0
		Walls - Below Grade	0.021	868		18
		Doors	0.400	0		0
		Windows	0.550	0		0
		Slab/Floor	0.008	961		8
				Wing UA Total	**25.6**	
2	**Main Library Area**	Ceiling to Loft	0.033	961		22
		Walls	**0.056**	664		37
				0		0
		Doors	0.400	23		9
		Windows	0.550	210		116
		1st Floor to Basement	0.171	961		165
				Wing UA Total	**348.8**	
3	**Room at Base of Stairs**	Roof	0.033	961		32
		Walls	**0.056**	153		9
				0		0
		Doors	0.400	0		0
		Windows	0.550	39		21
		Slab/Floor	0.171			0
				Wing UA Total	**61.7**	
4	**Loft Storage Area**	Roof	***0.016***	372		6
		Walls Vertical	**0.056**	190		11
		Sloped Roof Area	***0.038***	868		33
		Doors	0.400	0		0
		Windows	0.550	20		11
		Slab/Floor	0.008			0
				Wing UA Total	**60.4**	
				Building Total UA:	**496.5**	

INFILTRATION LOSSES

0.4

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	6,054	0.33	20	120	0.018	15	1.3	
		6,054	0.33	24	92	0.018	15	1.2	
	Occ.	6,054	0.00	4	120	0.018	20	0.0	2.5
2	**Main Library Area**	6,541	0.40	20	120	0.018	27	3.1	
		6,541	0.40	24	92	0.018	20	2.1	
	Occ.	6,541	0.50	4	120	0.018	35	1.0	6.1
3	**Room at Base of Stairs**	935	0.35	20	120	0.018	23	0.3	
		935	0.35	24	92	0.018	20	0.3	
	Occ.	935	0.35	4	120	0.018	25	0.1	0.7
4	**Loft Storage Area**	4,325	0.34	20	120	0.018	23	1.5	
		4,325	0.34	24	92	0.018	20	1.2	
	Occ.	4,325	0.34	4	120	0.018	25	0.3	2.9
						Infiltration Total			**12.2**