BALES ENERGY ASSOCIATES

Date: December 5, 2013

ENERGY STUDY
FOR

Riverside/ Four Winds School
54 French King Highway
Gill, MA 01354

Completed By:

Bales Energy Associates
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Introduction

Bales Energy Associates, an energy efficiency engineering firm, was contracted to provide an ASHRAE Level 2 energy audit for Riverside/Four Winds School located at 54 French King Highway 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 building's energy related systems.

Executive Summary

Energy Conservation Opportunities Evaluated

Bales Energy Associates has approached the Riverside/Four Winds School in terms of the whole system. Improvements in various systems have interactive impacts with other systems. Key conclusions are the following:

1. **Heating Systems Recommendation**
    - **Convert the existing steam system to hydronic operation using existing piping where feasible**
    - **Re-use existing radiators in the classrooms and historical room**
    - **Replace radiators not compatible with hydronic operation (in the hallway and office) with radiative panel convectors**
    - **Install a propane-fired, premium efficiency condensing hydronic boiler (with propane fuel storage tank capacity) to provide hot water to the building. Install necessary pump capacity to deliver heating water to the radiators and convectors serving building**
    - **Boiler replacement includes installation of microprocessor-based scheduling time-clock capabilities** to provide scheduling of occupied and unoccupied periods. Install an outdoor air temperature sensor and a space temperature sensor. Use space temperature and outside air sensor inputs sensors to determine when boiler and circulator shall run for daytime temperature maintenance, and unoccupied temperature setback.
2. **Enclosure Improvements** can substantially reduce the building's heat loss characteristics. Recommendations include:
    - **Insulate the attic area of the building to achieve an R-value of R60.** Add sufficient cellulose insulation (15 inches of blown cellulose to add approximately R55 to the existing ceiling assembly) to achieve the desired attic floor assembly R-value (R60). Air seal bypasses and penetrations in the attic. Seal off no longer used natural ventilation ductwork where it penetrates the ceiling.
    - **Install dense pack cellulose in the building walls cellulose (4 inches, R14)**.

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

	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 Condensing Boiler	$52,030	$17,138	0	$52,030	$17,138	1,777	-1,678	$1,689	30.8	10.1	30.8	10.1	20+
ECM2	Insulate & Air-Seal the Attic	$7,828	$7,828	0	$7,828	$7,828		308	$661	11.8	11.8	11.8	11.8	30+
ECM3	Insulate the First Floor Walls	$6,528	$6,528	0	$6,528	$6,528		851	$1,830	3.6	3.6	3.6	3.6	30+
	Totals	$66,386	$31,494	$0	$66,386	$31,494	1,777	-519	$4,180	15.9	7.5	15.9	7.5	

Existing Conditions

Facility Description

The Riverside/Four Winds School is a moderate sized wood-framed, sloped-roofed building located at 54 French King Highway, in Gill, Massachusetts. The building comprises a basement (currently used only for storage) and a first floor with two large classrooms, a former classroom now used by the historical society and administrative offices.

The building is owned by the town and currently leased to the Four Winds School.

Utility Energy Use

Utility data was collected and is tabulated below. Western Massachusetts Electric Company provides electricity. For heating, the Riverside/Four Winds School 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 2013ergy Use Table for Electricity & Fuel					
Building Name	**Riverside Building**				
Owner	**Town Of Gill, MA**				
Account #					
Month	Electricity KWH	Electricity Total $	Oil Gallons	Gas $	**Energy $ Totals**
Jul	109	*$24*			**$24**
Aug	122	*$27*			**$27**
Sept	212	*$47*	64.0	$191	**$237**
Oct	442	*$97*		$0	**$97**
Nov	422	*$93*	205.0	$611	**$703**
Dec	411	*$90*		$0	**$90**
Jan	544	*$120*	320.0	$953	**$1,073**
Feb	412	*$91*	695.0	$2,070	**$2,161**
Mar	375	*$83*	197.0	$587	**$669**
Apr	426	*$94*	296.0	$882	**$975**
May	325	*$72*			**$72**
Jun	237	*$52*			**$52**
Annual (Units)	4,037	$888	1,777.0	$5,292	**$6,181**
Heating Season (Units)	3,032	$667	1,777.0	$5,102	**$5,769**
				Energy Use Totals (Mbtu)	
Annual (Mbtu)	13,774		246,469.9	260,244	**Energy $ Totals**
Heating Season (Mbtu)	10,345		246,469.9	256,815	
$/Energy Unit				**Totals (Mbtu/sf)**	**($/sf)**
Annual (Mbtu/sf)	2.3		40.3	**42.6**	**$0.87**
Heating Season (Mbtu/sf)	1.7		40.3	**42.0**	**$0.83**
Htng Season $/Energy Unit					
Building Name	**Riverside Building**		**Heated Square Footage**		**6,114**

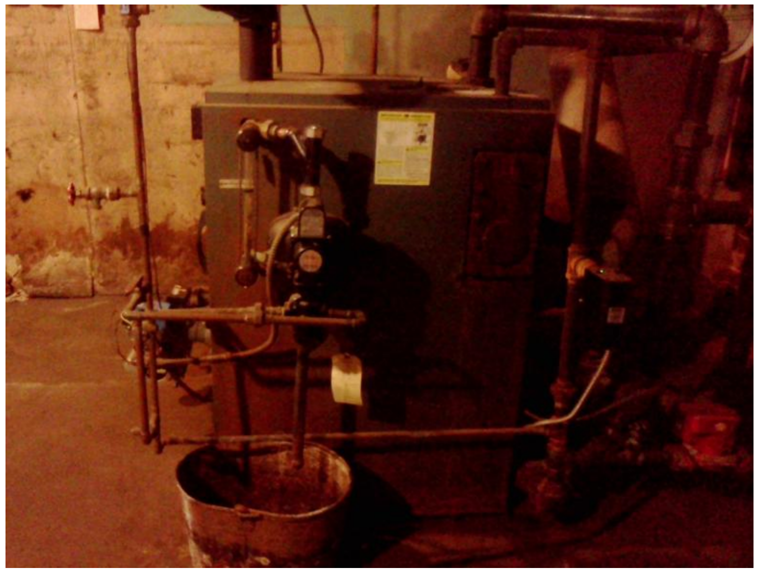
Prescriptive and custom utility incentives are available for some of the measures described. When the report's contents are accepted by the client, the report may be presented to the utilities for review and determination of levels of custom incentives the utilities will offer, if any.

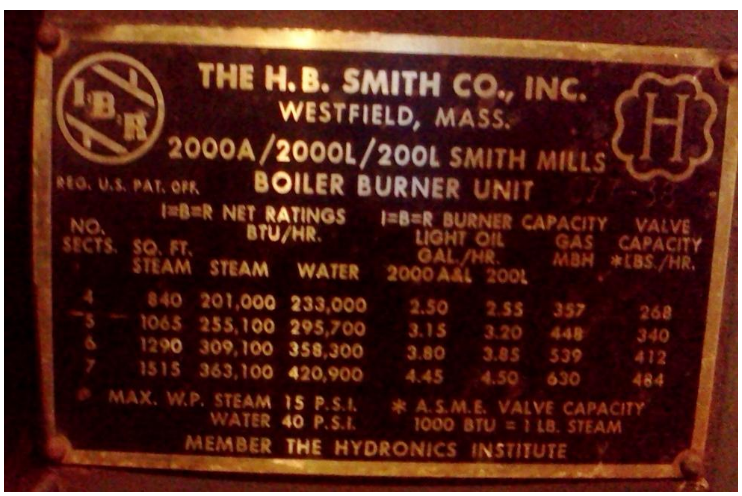
Western Massachusetts Electric Company contacts are: Lynn Ditullio (ditullb@nu.com) and Robert Dvorchik (dvorcrs@nu.com).

Heating, Ventilating & Air Conditioning Systems

Boiler

The building is served by a very old five-section, oil-fired, atmospheric steam boiler (HB Smith, 2000A/2000L/200L Mills) with a rated steam output capacity of 255,100 Btu/hour. The boiler has an estimated combustion efficiency of approximately 80%. (The most recent combustion test tag indicated performance at 65%, but the boiler appears to have been equipped more recently with a new Carlin burner.) There no outside air intake through the boiler wall to provide combustion air.





Recommended Boiler Improvement Measure

- **Convert the existing steam system to hydronic operation using existing piping where feasible**
- **Re-use existing radiators in the classrooms and historical room**
- **Replace the four radiators not compatible with hydronic operation (in the hallway and office) with radiative panel convectors**
- **Install a propane-fired, premium efficiency condensing hydronic boiler (with propane fuel storage tank capacity) to provide hot water to the building. Install necessary pump capacity to deliver heating water to the radiators and convectors serving building**
- **Boiler replacement includes installation of microprocessor-based scheduling time-clock capabilities** to provide scheduling of occupied and unoccupied periods. Install an outdoor air temperature sensor and a space temperature sensor. Use space temperature and outside air sensor inputs sensors to determine when boiler and circulator shall run for daytime temperature maintenance, and unoccupied temperature setback.

Heating Distribution Systems

The building is a one-pipe steam heating system (with a "drip leg" at the end of the supply line to allow condensate to return to the boiler (below the boiler's "water-line"). Given the convenient location of the steam piping running all the way around the perimeter of the building and the central location of the boiler, it is possible for the existing steam piping to be considered for re-use to deliver water as a heating medium with a limited amount of added piping required.

Prior to implementation of re-use of the steam pipe for water distribution pipe, it is recommended that the pipe be air-tested at elevated pressures to assess the potential presence of any leaks. (A hydronic system works at higher pressures than a steam system; a hydronic system might be expected to operate at approximately 60 psig, while a low-pressure steam system such as the one at the Riverside School would be expected to typically operate at pressures of 5 to 10 psig.)

Terminal heating is provided by radiators in all areas except one. The type of radiator found in the classrooms is shown below. It may be seen to be a one-pipe radiator with a steam valve on one end and an air relief valve on the other. The presence of screw fitting on the top and bottom manifolds of each end of the radiator indicate that these radiators were designed for use with either steam or hot water and that they are potentially able to be converted to hydronic operation.

Ceiling mounted radiators of similar function and slightly different configuration serve the seldom-used basement lavatories.

The four radiators in the office and the front hallways do not have top manifolds that connect the sections and are not equipped with screw fittings. These radiators are not as readily converted for use in a hydronic system. Thus, in converting the building to hydronic operation, these radiators would be recommended for replacement with convective radiator panels.

In one basement storage area (former cafeteria of many years ago) a length of ceiling mounted fin-tube radiation. This radiation may be potentially re-used for hydronic operation to provide heat to the storage area.

In the other large storage area in the basement (at one time used by the police department), it appears that a section n of radiation has been removed. In the final conversion of this building, an assessment of whether to add radiation to this area or not should be made.

Ventilation Considerations

The building was designed for thermally driven "natural" ventilation. Radiators located in ducts would provide sufficient heating of air in the ducts that it would rise to leave the building via large ducts leading to the large cupola on the top of the building. The air leaving the building would be replaced by un-tempered outside air leaking into the building through various elements of the building construction.

This system stopped being used when energy prices increased. One of the radiators in the ducts was noted to have been removed. Another duct radiator remained in place but the valve served it was locked closed. With no thermal energy to drive the process, cool air would sometimes "drop" down the ducts and bring cool air into the space to which it was attached.

In the picture below, it may be seen that the exhaust grill has been blocked with a rectangle of foam board to block the air flow.

Note that the metal ducts attached to this ventilation system are large and that they penetrate the ceiling and continue on into the unheated attic and then connect to the large metal cupola at the peak of the attic. In effect, these ducts located inside the building's thermal envelope, serve as fins to conduct thermal energy from the heated space to the unheated attic and also to the outdoors.

Since these ducts are no longer being used for ventilation, it may be useful to consider sealing the location where they pass through the ceiling. Though not an energy-savings measure in this particular case, the Town may wish to consider installing an energy-recovery ventilator to provide a more assured supply of outside air to the two classrooms when the air sealing and insulation measures are being completed. (Alternately, the spaces can continue to use the operable windows if added ventilation air is felt to be required.)

Building Temperature & Scheduling Controls

Operation of the boiler is controlled by a single manual thermostat serving the building.

As part of the boiler conversion replacement measure, Bales Energy Associates **recommends Installation of an electronic programmable timeclock capacity and an outdoor air sensor and an indoor space sensor.** Hydronic supply water temperatures would be reset to different levels depending on the outside air temperature. Outdoor temperature reset capability is critical to allow a boiler designed for condensing operation to actually condense the water vapor out of its exhaust to capture a greater percentage of the total energy available from the fuel being burned.

Domestic Hot Water Heating Systems

Hot water is provided by a 2.5 gallon mini-tank tank electric water heater (Ariston Model 2.5 Ti). Given eh very low water use in the building, this is an efficient way to provide the limited quantities of warm water that are required. Water usage is low in the building; water uses are limited to a lavatory sink on the first floor. Other than encouraging the town to insulate the three feet of un-insulated ½ inch domestic hot water pipe leading from the mini-tank in the basement to the lavatory on the floor above, Bales Energy Associates makes no recommendations with regard to domestic hot water system improvements.

Electrical Systems

Lighting Systems

Classrooms and offices in the building are lighted with four foot fluorescent fixtures equipped with T-8 lamps and compatible electronic ballasts.

Building Enclosure

The partially finished basement and first floor of the Riverside/Four Winds School comprise approximately 6,114 square feet of heated floor area. All school activities take place on the first floor which comprises two classrooms and administrative offices, plus one classroom which is used by ht e historical society.

The basement is currently only used for storage.

Roof and Attic

The Riverside/Four Winds School has a sloped-roof with a metal ventilation cupola on top.

The attic is unfloored and has 2 to 3 inches of rock wool insulation in place. Large metal ductwork designed for use by the heat-driven natural ventilation system penetrates the first floor ceiling and continues on through the attic to the metal exhaust cupola on the roof. The ducts represent a large air bypasses. There also bypasses from the first floor to the attic through the spaces around the duct work.

Recommendation for the Attic

Bales Energy Associates recommends that the attic floor joists be treated as the location thermal and air boundary layer. This involves the following steps:

1. Retain the cupola for ventilation out of the attic.
2. Insulate the attic floor assembly to add approximately 15 inches of loose-fill cellulose insulation (R55) to the attic to achieve a roof assembly value of R-60.
3. Air-seal the attic area to reduce infiltration.

Costs and savings for this measure are included in the Appendices.

Walls

The walls of the Riverside/Four Winds School are poorly insulated.

Recommendation for the Wall

Bales Energy Associates recommends that insulating the four inch wall assembly with approximately four inches of high-density cellulose (R14) insulation.

Costs and savings for this measure are included in the Appendices.

APPENDICES

HEATING SYSTEM IMPROVEMENT MEASURES

Conversion of System to Hydronic (Hot Water) Operation & Installation of Propane-Fired Condensing Hydronic Boiler

			Space Heating Savings with Propane-Fired Condensing Hydronic Boiler			
			Gill Riverside/Four Winds School		Propane	
Oil Rate ($/gallon)			Gill, MA		$/gallon	
$2.98	Existing Condition:			New Condition:	$2.15	
Equipment Type	Space Heating Boiler			Space Heating Boiler	Space Heating Boiler	
Boiler #	1			1		
Make	H B Smith			Lochinvar		
Model	2000A/2000L/200L Mills			Knight		
Type	Atmospheric			Condensing		
Heating Medium	Steam			Hydronic		
Control Mode				Modulating 5:1		
ximum Output Mbtu/	255			150		
Steady State Eff	80%			92%		
Input Mbtu/Hr	319			163		
Seasonal Eff	65%			92%		
Percentage of Load	100%			100%		
stalled System Costs		High-Performance Heating System				
Boiler	$34,892	Propane-Fired Condensing Boiler with 4 new radiators, conversion of other existing radiators, circulator, controls and required piping changes		$40,030		
		Propane tank		$7,000		
		System Configuration Contractor Oversight		$5,000		
Totals	$34,892			$52,030		
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
160,205	Existing Oil Use	1,777		$5,295	150	150
160,205	New Propane Use		1,678	$3,607		
		KWH				
Fuel Energy Before	246,470					
Fuel Energy After	174,136					
uel Energy saved	72,334		Savings $	$1,689		
Payback Calculation:						
		Cost	Savings	Payback		
Full Equipment Cost Basis:		$52,030	$1,689	30.8		
Incremental Equipment Cost Basis:		$17,138	$1,689	10.1		

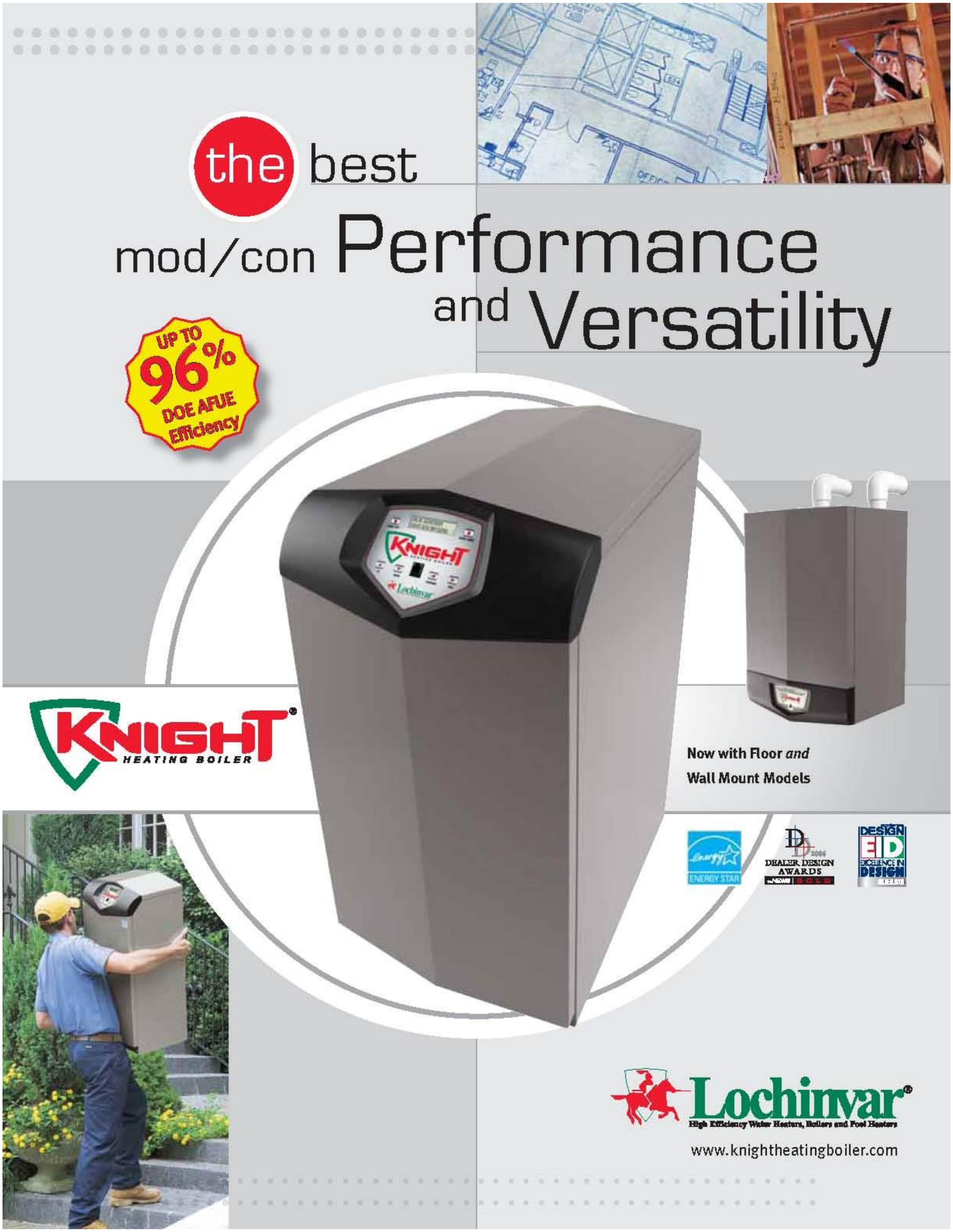
LOCHINVAR BOILERS

For more than 80 years, Lochinvar has played a legendary role in commercial water heating. Now we're bringing that proven performance to the condensing market with the KNIGHT—today's most advanced fully modulating high-efficiency condensing boiler.

The KNIGHT is an installer's dream: lightweight and compact, with key components that are easy to access. The Lochinvar KNIGHT offers PVC venting versatility, rugged reliability, seven models with inputs ranging from 80,000 to 500,000 Btu/hr, and 93% DOE AFUE. And you'll love the SMART SYSTEMª control, which includes a service indicator, contractor accessible password protection, and a 2-line display with simple fault descriptions, not codes. Best of all, the KNIGHT offers more standard features than any other heating boiler available today—including outdoor reset and a boiler circulating pump supplied with every KB 080-285 unit. Plus every KNIGHT is backed by an outstanding 12-year warranty.

1.1 FEATURES

- Stainless steel heat exchanger
- Fully modulating burner w/5:1 turndown
- PVC venting - up to 100 ft.
- Boiler circulating pump included
- Direct vent, sealed combustion


the best
mod/con Performance
and Versatility
UP TO 96% DOE AFUE Efficiency
KNIGHT
HEATING BOILER
Now with Floor and Wall Mount Models
DEALER DESIGN AWARDS
Lochinvar
www.knightheatingboiler.com

a Legendary Performer…

KNIGHT® HEATING BOILER

Since its introduction in 2005, the KNIGHT modulating-condensing heating boiler has consistently delivered everything the professional needs for ease of installation and maintenance, and everything homeowners need for total comfort and long-term savings on energy costs.

Now, with 5 floor-standing models and 5 compact Wall Mount units, Lochinvar offers the industry's broadest selection of modulating-condensing heating boilers. And KNIGHT is the industry's most advanced boiler design, including the SMARTSYSTEM™ operating control that has quickly become a legendary benchmark among the trade!

For traditional space heating or radiant floor heating applications, KNIGHT offers your customers tremendous savings on energy costs compared to less efficient boilers. KNIGHT has earned the ENERGY STAR, signifying that it has met strict energy-efficiency guidelines set by the EPA and U.S. Department of Energy.

10 Models – The Right Choice, for Every Application

"After my first KNIGHT installation, I loved it so much I installed it in my own home, and now my heating bill is half what it used to be."
– Rick Brunner, Hydronic Solutions, Nassau County, NY

KNIGHT is a great choice for radiant floor heating, baseboard and panel heater applications.

is joined at the Round Table

KNIGHT™ WALL MOUNT BOILER

"Why do I like the KNIGHT? I don't know where to begin. The direct venting with 100 feet of intake and exhaust eliminates a lot of problems. I also like the low voltage features, and the SMART SYSTEM's outdoor reset capability. The internal sequencer is tremendously powerful and ideal for multiple boiler installations. It's also great-looking, and aesthetics are important to my customers. When I install KNIGHT, my customers know they are getting a highly efficient state-of-the-art system, and they've all been completely satisfied."

– Paul Rohrs, Biggerstaff Radiant Solutions, Lincoln, NE

KNIGHT lineup now includes 5 space-saving Wall Mount models from 50,000 to 210,000 Btu/hr

The KNIGHT floor-standing lineup features 5 small footprint designs from 80,000 to 285,000 Btu/hr

All KNIGHT Boilers meet or exceed the highest federal emissions requirements.

KNIGHT plus SQUIRE delivers domestic hot water for less!

The KNIGHT boiler's DHWP feature means you can easily install it with Lochinvar's new SQUIRE indirect water heater. With this winning combination, homeowners will get high-efficiency space heating from KNIGHT, plus all the domestic hot water they need from SQUIRE. Equipped with a stainless steel tank and heat exchanger, SQUIRE will provide more hot water with lower water heating costs compared to a standard gas or electric water heater.

SMART SYSTEM

& the Industry's Smartest Design

SMART SYSTEM is the industry's most advanced operating control. Right out of the box, it gives you unequaled control and monitoring functions that are easy to understand and use.

"I really like the KNIGHT Boiler because it's very simple to install and program. The SMART SYSTEM control is great and I really like being able to troubleshoot with the pocket PC. My customers choose KNIGHT for its high efficiency and state-of-the-art design, and they're all thrilled that KNIGHT operates so quietly and makes their home much more comfortable."

– Chad Padilla, TLC Plumbing, Albuquerque, NM

2-Line, 16-Character LCD Display
Displays setup and diagnostic information in words, not codes

Password Security
Dual passwords for installer and user

Product Service Indicator
Program reminders for cycle count, operation hours or last service

Pump Relay w/Freeze Protection
Ensures water temperature does not fall below 40°F

Low-Water Flow Indicator
Protects against high temperature differential in the heat exchanger with reduced modulation or shutdown

Outdoor Reset
Outdoor temperature monitor guides the reset schedule to meet load

Night Setback
Program a heating loop water temperature setback for any time of the day, each day of the week

Building Management System (BMS) Control
0-10 VDC, BMS-driven input for modulation rate or temperature control

DHWP with Pump Control
On call for hot water, SMART SYSTEM overrides outdoor reset and starts DHWP pump to the indirect. Runtime can alternate between heating and domestic hot water to meet demand simultaneously

System & Boiler Pump Controls
Provides power to both system and boiler pumps based on a call for heat. Programmable delay allows pumps to operate after a call has been satisfied

In/Out Temp. Sensors and Display
Allows installer to select which sensor controls the boiler setpoint

PC Connection –
Can be used with KNIGHT PC or Pocket PC software to troubleshoot and program SMART SYSTEM functions and to track historical data, including faults, trends and energy consumption.

Field Connection Versatility
User-friendly terminal strip allows for 28 low-voltage field connections. Plus, 4 line voltage connections supply power to the unit, and up to three pumps operated by the SMART SYSTEM.

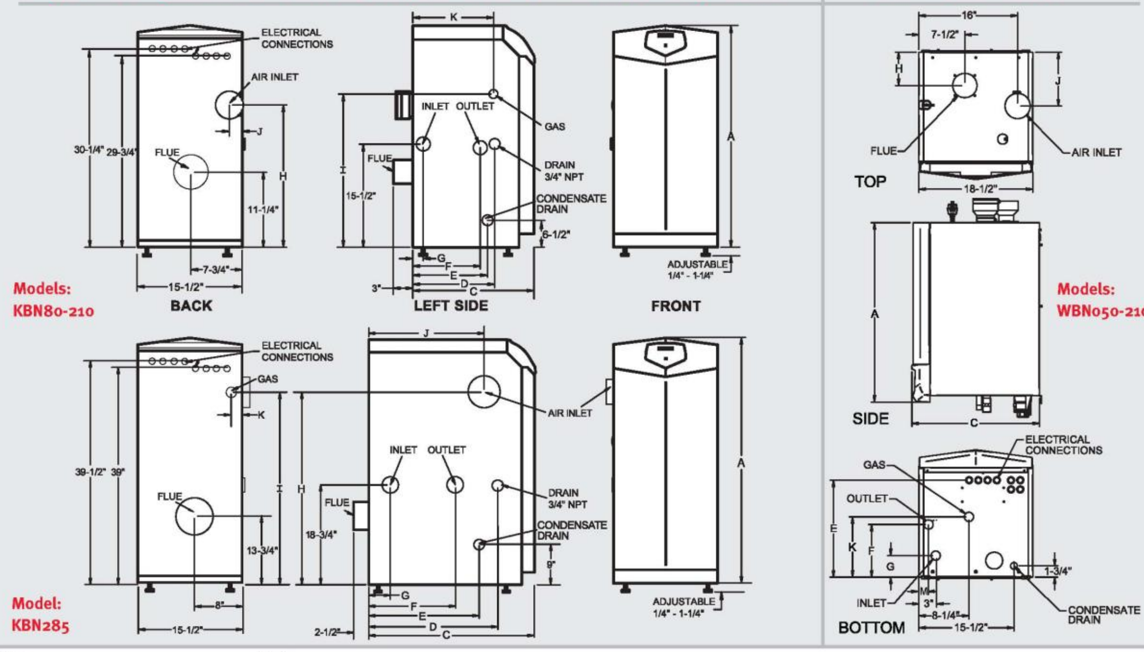
Built-in Cascading Sequencer
SMART SYSTEM includes a built-in sequencer for 2–8 units, eliminating the cost and labor of a third-party sequencer. On demand, one boiler acts as lead unit and modulates with demand to meet capacity. The additional load then "cascades" to the next boiler in line and continues all are operating or demand is satisfied. When demand drops, the process reverses.

"The control system on the KNIGHT is head and shoulders above anything else available. ***Straight out of the box, the KNIGHT can do anything I need without third-party controls.*** *Hands-down, it's the best boiler on the market."*

– Don Smet, Standard Plumbing Heating Controls Corp., Spokane, WA

Knight Heating Boiler Dimensions & Specifications– Floor Standing Models

Wall Mount Models



KNIGHT Heating Boiler						Dimensions and Specifications																
Model Number	Input Min MBH	Input Max MBH	AFUE %	Heating Capacity MBH	NET I=B=R MBH	A	C	D	E	F	G	H	I	J	K	M	Gas Conn.	Water Conn.	Air Inlet	Vent Size	Shipping Weight
WBN050	10	50	95.3	45	39	29-1/4"	15-3/4"	NA	10-3/4"	10-3/4"	2"	6-3/4"	NA	3-1/4"	4-1/4"	2-3/4"	1/2"	1"	2"	2"	130
WBN080	16	80	95.3	72	63	29-1/4"	15-3/4"	NA	10-3/4"	10-3/4"	2"	6-3/4"	NA	3-1/4"	4-1/4"	2-3/4"	1/2"	1"	2"	2"	130
WBN105	21	105	95.4	97	82	29-1/4"	15-3/4"	NA	10-3/4"	10-3/4"	3-1/2"	5-1/2"	NA	3-1/4"	4-1/4"	2-3/4"	1/2"	1"	2"	2"	134
WBN150	30	150	95.5	135	119	29-1/4"	20-3/4"	NA	15-3/4"	8-1/2"	3-1/2"	5-1/2"	NA	8-3/4"	9-3/4"	1-1/2"	1/2"	1"	3"	3"	162
WBN210	42	210	95.7	190	165	29-1/4"	25"	NA	20"	12"	3-1/2"	5-1/2"	NA	13"	14"	1-1/2"	1/2"	1"	3"	3"	177
KBN080	16	80	95.3	72	63	33-1/4"	14"	7"	5-3/4"	5"	3"	20-1/2"	22"	1-3/4"	6-1/2"	NA	1/2"	1"	3"	3"	125
KBN105	21	105	95.4	97	82	33-1/4"	14"	6-1/2"	5-3/4"	4-1/2"	1-1/2"	20-1/2"	22"	1-3/4"	6-1/2"	NA	1/2"	1"	3"	3"	129
KBN150	30	150	95.5	135	119	33-1/4"	18"	12-1/4"	11-1/2"	10"	1-1/2"	21-1/4"	23"	1-3/4"	12"	NA	1/2"	1"	3"	3"	157
KBN210	42	210	95.7	190	165	33-1/4"	22-1/4"	16-1/2"	15-3/4"	14-1/4"	5-1/4"	21-1/4"	23"	1-3/4"	16-1/4"	NA	1/2"	1"	3"	3"	172
KBN285	57	285	96.0	260	226	42-1/2"	19-3/4"	12-3/4"	13-1/2"	6"	2"	34"	31"	11-3/4"	4-1/4"	NA	3/4"	1-1/4"	4"	4"	224

Notes: Performance data based on manufacturer's test results. Indoor installation only. All information subject to change. Change "N" to "L" for LP gas models.

Standard Features

*Standard features in **BOLD** text indicate equipment you would pay extra for on competing models.*

- ENERGY STAR® Qualified
- Modulating Burner with 5:1 Turndown
- ASME Stainless Steel Heat Exchanger
- Gasketless Heat Exchanger Design
- 30 psi Relief Valve
- **SMART SYSTEM™ Operating Control, with:**
  - **Digital Operating Control**
  - **2-Line, 16-Character LCD Display**
  - **Password Security**
  - **Outdoor Reset**
  - **Built-in Sequencing for 2-8 Boilers**
  - **0 – 10 Vdc Input Control**
  - **Product Service Indicator**
  - **Time Clock**
  - **PC Connection Port**
- Inlet & Outlet Temperature Sensors
- Easy-Access Terminal Strip
- Low-Water Flow Indication
- Automatic Reset High Limit
- **Contacts on Any Failure**
- **3-Pump Control (Boiler, System and DHWP)**
- Pump Relay with Freeze Protection
- **Boiler Circulating Pump (KBN080-285) (WBN050-210)**
- Direct-Spark Ignition
- Low-NOx Operation
- Natural to LP Gas Conversion Kit
- Direct-Vent Sealed Combustion
- PVC Venting up to 100 Feet
- Sidewall Vent Terminals
- Zero Clearance to Combustibles
- Adjustable Leveling Legs (KBN Models only)
- Wall Mount Bracket (WBN Models only)
- 12-Year Limited Warranty (See Warranty for Details)

Optional Equipment

- Adjustable High Limit with Manual Reset
- Flow Switch
- Low-Water Cutoff with Manual Reset and Test
- Alarm Bell on Any Failure
- SMART SYSTEM™ PC Software
- Concentric Vent Kit
- Condensate Neutralization Kit
- Multi-Stack Frame (KBN Models only)

Lochinvar® High Efficiency Water Heaters, Boilers and Pool Heaters

300 Maddox Simpson Parkway, Lebanon, TN 37090 | 615-889-8900 | fax: 615-547-1000 | www.lochinvar.com

KBN-04 (Replaces KBN-03 8/07) MK-20M-2/08-Printed in U.S.A.

WALL & ATTIC INSULATION MEASURE INFORMATION

School

	Location	Measure	Depth	R-Value	# / SF	Cost
1	Walls	Cellulose Net & Blow	4	14	3,264	$6,528
2	Attic Floor	Cellulose Open Blow	9	33	3,260	$4,727
3	Attic Floor	Cellulose OB to R60 Adder	6	22	3,260	$1,141
4	Attic	Air Sealing	0	N/A	20	$1,400
5	Attic	Duct Capped & Sealed	0	N/A	6	$660
6					0	$0
	Total					$14,456

* Assumes that ductwork will be removed to the attic floor and left clean for air sealing.
Insulation costs were provided by EnergiaUS located in Holyoke, MA.

Energía, LLC
242 Suffolk Street
Holyoke, MA 01040
(413) 322-3111

ECM#2	Summary of Energy Savings Due to Attic Insulation				
	Baseline Heat Load MMBTU	After ECM #2 MMBTU	Savings 10E6 Btu/yr	% Reduction	
Fuel Energy Usage (MMBtu/yr)	159.43	130.20	29.23	18.3%	
New Boiler System efficiency	92%	92%			
Fuel Energy Usage (MMBtu/yr)	173	142			
Energy Savings	% Reduction	Propane Use after ECM1	Gallons Saved	$/Unit	$ Saved
	18.3%	1,678	308	$2.150	$661
				Total Savings ($)	$661

			Cost	Savings	Payback
Attic Insulation&		Measure	$	$	Years
Air Sealing	$7,828	ECM2	$7,828	$661	11.8

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

ECM#3	Summary of Energy Savings Due to Wall & Attic Insulation				
	Baseline Heat Load MMBtu	After ECM #2 MMBtu	Savings 10E6 Btu/yr	% Reduction	
Fuel Energy Usage (MMBtu/yr)	130.20	49.31	80.89	62.1%	
New Boiler System efficiency	92%	92%			
Fuel Energy Usage (MMBtu/yr)	142	54			
Energy Savings	% Reduction	Propane Use after ECM1 &2	Gallons Saved	$/Unit	$ Saved
	62.1%	1,370	851	$2.150	$1,830
				Total Savings ($)	$1,830

		Measure	Cost $	Savings $	Payback Years
Wall Insulation	$6,528	ECM3	$6,528	$1,830	3.6

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

ANNUAL BUILDING HEAT BALANCE

EXISTING CONDITIONS

HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-184.7
INFILTRATION LOSSES	-51.6
VENTILATION LOSSES	0.0
SOLAR GAIN	60.5
OCCUPANT GAIN	6.6
ELECTRICAL GAIN	9.8
NET HEATING DEMAND	-159.4

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
159.4	246	65%

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	264	6	0	20	0	
		264	18	0	20	0	
		264	24	212	20	27	26.9
2	**First Floor Main**	1,008	6	140	35	30	
		1,008	18	140	25	63	
		1,008	24	72	20	35	127.9
3	**First Floor Office**	236	6	140	35	7	
		236	18	140	25	15	
		236	24	72	20	8	29.9
	Total UA	**1,507**		**Conduction Total**			**184.7**

				INFILTRATION LOSSES					
			0.4						
#	**Zone**	**VOLUME**	**ACH**	**HRS/ DAY**	**DAYS/ YR**	**0.018**	**TEMP DIFF**	**LOSSES (* 1E6)**	**Sub Totals**
1	**Basement**	20,758	0.40	18	0	0.018	20	0.0	
		20,758	0.40	24	212	0.018	20	15.2	
	Occ.	20,758	0.40	6	0	0.018	20	0.0	15.2
2	**First Floor Main**	31,136	0.45	18	140	0.018	25	15.9	
		31,136	0.45	24	72	0.018	20	8.7	
	Occ.	31,136	0.48	6	140	0.018	35	7.9	32.5
3	**First Floor Office**	3,758	0.45	18	140	0.018	25	1.9	
		3,758	0.45	24	72	0.018	20	1.1	
	Occ.	3,758	0.48	6	140	0.018	35	1.0	3.9
						Infiltration Total			**51.6**

HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Basement**	Roof	0.097	0		0
		Walls	0.302	675		204
		Below grade	0.000	1,240		0
		Doors	0.625	42		26
		Windows	0.400	27		11
		Slab/Floor	0.008	2,883		23
				Wing UA Total	**264.1**	
2	**First Floor Main**	Roof	0.097	2,883		205
		Walls	0.279	2,119		591
			0.000	0		0
		Doors	0.625	36		23
		Windows	0.400	473		189
		Slab/Floor	0.040	0		0
				Wing UA Total	**1007.7**	
3	**First Floor Offices**	Roof	0.097	348		34
		Walls	0.279	548		153
			0.000	0		0
		Doors	0.625	0		0
		Windows	0.400	88		35
		Slab/Floor	0.040	348		14
				Wing UA Total	**235.6**	
				Building Total UA:	**1507.4**	

Riverside Building

Window Solar Heat Gain

Window Orientation	Solar Heat Gain Factor (BTU/SF) Heating Season 40 N Latitude	Window Area	Shading Factor (Max = .52)	Total BTU per Heating Season *E6
North	37,730	220	0.49	4.1
Northeast	58,231	0	0.49	0.0
South	315,304	363	0.49	56.1
Southeast	256,605	0	0.49	0.0
East	150,216	0	0.49	0.0
Northwest	58,231	0	0.49	0.0
West	150,216	5	0.49	0.4
Southwest	256,605	0	0.49	0.0
	Totals	588		60.5

Temperature & Schedule Information

Building Name: **Riverside Building**

Total Heating Days	212	Floor SF
Outdoor Winter Temperature	35	6,114

	Wing name	**Occupied Temp.**	**Unoccupied Temp. Night**	**Off days**	**Htg System Occ. Hrs per day ***	Includes 1.5 warm-up period **Schedule**	**Occ Level Heating Days**
1	Basement	55	55	55	6	not in use	0
2	First Floor Main	70	60	55	6	in use 5 days per week	140
3	First Floor Offices	70	60	55	6	in use 5 days per week	140

ANNUAL BUILDING HEAT LOADS

AFTER ATTIC INSULATION &

AIR SEALING

HEAT LOAD AFTER ATTIC INSULATION	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-159.5
INFILTRATION LOSSES	-47.7
VENTILATION LOSSES	0.0
SOLAR GAIN	60.5
OCCUPANT GAIN	6.6
ELECTRICAL GAIN	9.8
NET HEATING DEMAND	-130.2

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Basement	264	6	0	20	0	
		264	18	0	20	0	
		264	24	212	20	27	26.9
2	First Floor Main	837	6	140	35	25	
		837	18	140	25	53	
		837	24	72	20	29	106.3
3	First Floor Office	208	6	140	35	6	
		208	18	140	25	13	
		208	24	72	20	7	26.3
	Total UA	**1,309**			**Conduction Total**		**159.5**

INFILTRATION LOSSES

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Basement	20,758	0.40	18	0	0.018	20	0.0	
		20,758	0.40	24	212	0.018	20	15.2	
	Occ.	20,758	0.40	6	0	0.018	20	0.0	15.2
2	First Floor Main	31,136	**0.40**	18	140	0.018	25	14.1	
		31,136	**0.40**	24	72	0.018	20	7.7	
	Occ.	31,136	**0.43**	6	140	0.018	35	7.1	29.0
3	First Floor Offic	3,758	**0.40**	18	140	0.018	25	1.7	
		3,758	**0.40**	24	72	0.018	20	0.9	
	Occ.	3,758	**0.43**	6	140	0.018	35	0.9	3.5
							Infiltration Total		**47.7**

		HEAT LOSS COEFFICIENTS				
Zone #	**Building Zone**		**U-Value (BTU/hr-sf-F)**	**Area (sf)**		**UA-Value (BTU/hr-F)**
1	**Basement**	Roof	0.015	0		0
		Walls	0.302	675		204
		Below grade	0.000	1,240		0
		Doors	0.625	42		26
		Windows	0.400	27		11
		Slab/Floor	0.008	2,883		23
			Wing UA Total		**264.1**	
2	**First Floor Main**	Roof	**0.016**	2,883		34
		Walls	0.279	2,119		591
			0.000	0		0
		Doors	0.625	36		23
		Windows	0.400	473		189
		Slab/Floor	0.040	0		0
			Wing UA Total		**837.0**	
3	**First Floor Offices**	Roof	**0.016**	348		6
		Walls	0.279	548		153
			0.000	0		0
		Doors	0.625	0		0
		Windows	0.400	88		35
		Slab/Floor	0.040	348		14
			Wing UA Total		**207.5**	
			Building Total UA:		**1308.6**	

ANNUAL BUILDING HEAT LOADS

AFTER WALL INSULATION &

ATTIC INSULATION &

AIR SEALING

HEAT LOAD AFTER WALL & ATTIC INSULATION	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-78.6
INFILTRATION LOSSES	-47.7
VENTILATION LOSSES	0.0
SOLAR GAIN	60.5
OCCUPANT GAIN	6.6
ELECTRICAL GAIN	9.8
NET HEATING DEMAND	-49.3

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Basement**	111	6	0	20	0	
		111	18	0	20	0	
		111	24	212	20	11	11.3
2	**First Floor Main**	428	6	140	35	13	
		428	18	140	25	27	
		428	24	72	20	15	54.4
3	**First Floor Office**	102	6	140	35	3	
		102	18	140	25	6	
		102	24	72	20	4	12.9
	Total UA	**641**		**Conduction Total**			**78.6**

HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Basement**	Roof	0.015	0		0
		Walls	0.075	675		51
		Below grade	0.000	1,240		0
		Doors	0.625	42		26
		Windows	0.400	27		11
		Slab/Floor	0.008	2,883		23
				Wing UA Total	**111.0**	
2	**First Floor Main**	Roof	**0.016**	2,883		34
		Walls	**0.086**	2,119		182
			0.000	0		0
		Doors	0.625	36		23
		Windows	0.400	473		189
		Slab/Floor	0.040	0		0
				Wing UA Total	**428.3**	
3	**First Floor Offices**	Roof	**0.016**	348		6
		Walls	**0.086**	548		47
			0.000	0		0
		Doors	0.625	0		0
		Windows	0.400	88		35
		Slab/Floor	0.040	348		14
				Wing UA Total	**101.7**	
				Building Total UA:	**641.1**	