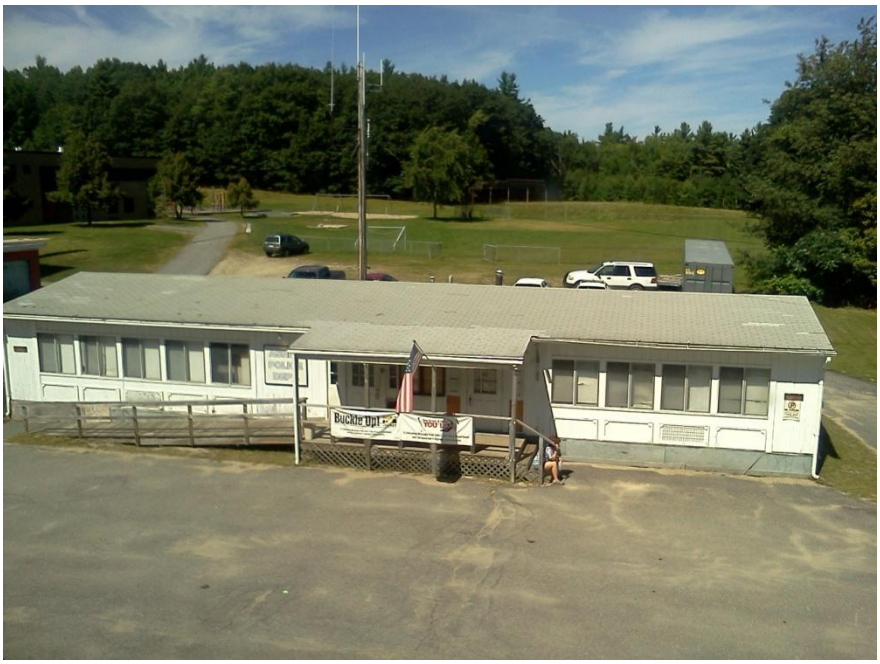
BALES ENERGY ASSOCIATES

Date: September 16, 2014
(Revised: December 19, 2014)

DRAFT PROGRESS REPORT
ENERGY STUDY
for the
Ashby Police Department



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 Police Station, located at 893 Main Street.

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 either 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.

Building envelope improvements, both adding insulation and air sealing, and space conditioning temperature controls were the focus of the study at the Ashby Police Department.

Key conclusions are the following:

1. **Enclosure Improvement Options:** These can substantially reduce the building's heat loss characteristics. Recommendations include:

- **ECM 1.1 - Insulate the floor above the crawl space levels.** Add sufficient insulation to increase the floor assembly R-value to R24. Air seal bypasses and penetrations in the floor.

OR

- **ECM 1.2 - Construct a sealed and insulated crawl space below the building.** Remove the existing plywood that wraps the base of the building and replace it with an insulated 'wall'. Also apply layer of plastic over the ground surface and completely seal at the seams and edges.

2. **HVAC System Recommendation Options:**
   - **ECM 2.1 - Separate the building into two zones.** Install a secondary air damper and a microprocessor-based programmable thermostat to allow for separate temperature control and setback for locker room side of the station.

OR

- **ECM 2.2 - Install an air source heat pump system (ASHP).** Replace the existing oil-fired furnace with and super efficient mini-split style ASHP to both heat and cool the building.

Though outside the scope of the building related services contracted and addressed in this report, BEA recognizes that idling of police vehicles represents a significant energy use. BEA recommends implementation of a policy to minimize vehicle idling to realize the potential savings.

The costs, savings, and economic payback for these energy conservation measures are presented in the following Executive Summary Chart. The values shown 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

Executive Summary Chart

Green Communities Study

Natural Gas	Propane	Oil	Electricity
per therm	per gal	$3.24 per gal	$0.17 per kWh

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Available Incentive ($)	Fuel Energy Savings (% of base)	Annual Savings ($ / yr)	Full Cost: Cost ($)	Full Cost: Payback (yrs)	Full Cost: After Incentive Cost ($)	Full Cost: After Incentive Payback (yrs)	Incremental Cost Difference *: Cost ($)	Incremental Cost Difference *: Payback (yrs)	Incremental Cost Difference *: After Incentive Cost ($)	Incremental Cost Difference *: After Incentive Payback (yrs)
ECM 1.1	Insulate & Air Seal the Floor	$ -	51%	$ 1,348	$ 13,883	10.3	$ 13,883	10.3	$ 13,883	10.3	$ 13,883	10.3
OR												
ECM 1.2	Construct Insulated & Sealed Crawlspace	$ -	47%	$ 1,261	$ 12,966	10.3	$ 12,966	10.3	$ 12,966	10.3	$ 12,966	10.3
ECM 2.1	Energy Management System Controls	$ -	10%	$ 273	$ 1,750	6.4	$ 1,750	6.4	$ 1,750	6.4	$ 1,750	6.4
OR												
ECM 2.2	Heating with Air Source Heat Pump (ASHP)	$ -	40%	$ 1,174	$ 24,452	20.8	$ 24,452	20.8	$ 24,452	20.8	$ 24,452	20.8

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

Fuel Energy Reduction Chart

		Fuel Energy Impact						
		Natural Gas	Propane	Oil	Electricity			
		100.0 kBtu / therm	92.5 kBtu / gal	138.7 kBtu / gal	3.413 kBtu / kWh			
Baseline Energy Use		Natural Gas	Propane	Oil	Electricity	Fuel Energy		
Space Heating & Domestic Hot Water				823		114,095		
Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures: Natural Gas (gal / yr)	Propane (gal / yr)	Oil (gal / yr)	Electricity (kWh / yr)	Fuel Energy Use (kBtu / yr)	Fuel Energy Savings (kBtu / yr)	Savings As % of Baseline
ECM 1.1	Insulate & Air Seal the Floor			407		56,465	57,629	51%
OR								
ECM 1.2	Construct Insulated & Sealed Crawlspace			434		60,189	53,906	47%
ECM 2.1	Energy Management System Controls			323		44,790	11,676	10%
OR								
ECM 2.2	Heating with Air Source Heat Pump (ASHP)				3,247	11,080	45,385	40%

Existing Conditions

Facility Description

This facility is an old single-wide modular-style building. It is understood that the department was moved into this space after it was vacated by the elementary school when it was used by them during a school renovation project. The department uses it 7 days a week and it's occupied by at least one person 24 hours per day. The structure is not efficient from either an energy or department needs perspective.

Utility Energy Use

Utility data for a multi-year period was collected and reviewed. Data for the (May 2013 - April 2014) reference year used for heat balance purposes is tabulated and reported in the appendices. For that period, the annual electrical usage was 45,620 kWh; the annual oil consumption was 822 gallons. Energy usage expressed in common energy units resulted in an annual total of 269,750 kBtu per year. Per heated square foot of floor area, energy usage was a relatively high value of 152.8 kBtu/ft^2.

Building Enclosure

The building has an asphalt shingle roof over an SIP type panel roofing system of approximately 6" thickness forming a vaulted/cathedral ceiling inside. The exterior walls are wood frame 2" x 4" structure and are assumed to have fiberglass batt insulation in the stud cavity though the assigned r-value used in the heat balance calculations are reduced to only R-6 to account for poor condition being assumed. The floor is perhaps the largest contributor to the poor envelope conditions in the space. The combined r-value assigned to this building component is R-3.6. Windows are single pane glass, sliding units all on the front wall facing southwest.

Recommendation: Building Enclosure Improvements

Bales Energy Associates recommends reducing heat loss through the floor of the building. This could be accomplished by either of the following approaches: *(Note: In both methods, any plumbing and mechanicals exposed to the air would be sealed and insulated appropriately to limit exposure to freezing and heat loss.)*

- **ECM 1.1 - Insulate the floor above the crawl space level.** Add sufficient insulation to increase the floor assembly R-value to R24. Air seal bypasses and penetrations in the floor. This measure was calculated using open cell spray-applied foam insulation to the floor assembly between the occupied area and the crawl space.

OR

- **ECM 1.2 - Construct a sealed and insulated crawl space below the building.** This would require removing the existing plywood and frame structure that currently serves to minimize animal activity under the structure and provides a slight barrier that limits air and temperature impact on the floor and existing piping and mechanicals below. A new frame would be constructed to secure 4" of foam board insulation to and would hold an exterior layer over the insulation to protect it. In addition, a layer of plastic sheeting would be applied to the entire ground surface inside this perimeter to serve as a moisture/vapor barrier. This plastic would have taped seams, be folded up at the edges and taped to the wall.

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

Heating, Ventilation & Air Conditioning Systems

Furnace

The furnace used to heat the space is a Rheem Imperial oil-fired furnace with an input of 105 MBH at 0.75 GPH burner input. The gross output is therefore 104,025 Btu/hr.

The modeled design heat load for the building as currently configured and designed is approximately 66,000 Btu/hr.

After the completion of the recommended Energy Conservation Measures (ECM), the design heat load of the building was calculated to be 51,000 Btu/hr. Sizing of the heating system in this report assumes the lower design heat load required after implementation of the recommended enclosure improvement measures. All estimates and quotes were based on this value.

Note: Any future quotations and heat load calculations should take into account any design heat load reductions due to implementation of the measures recommended in this report.

Recommendation: <u>Heating System Improvement Options</u>

- **ECM 2.1 - Separate the building into two zones.** If retaining the existing furnace system to heat the building, install a secondary air damper and a microprocessor-based programmable thermostat to allow for separate temperature control and setback for locker room side of the station.

OR

- **ECM 2.2 - Install an air source heat pump system (ASHP).** Replace the existing oil-fired furnace with and super efficient mini-split style ASHP to both heat and cool the building. This option also evaluated separating the building into two zones and included the installation of two (2) outdoor compressor units and two (2) wall-mounted indoor units (one paired set for each zone). These units would be sized to supply 100% of the design heat load to the building.

Heating & Cooling Distribution System

The heating distribution system consists of supply and return ducting to/from the conditioned space. All supply ductwork, which comes off the downdraft furnace from below it, is located beneath the floor. Though a visual inspection of the ducting was not possible on the day of the walk through, it is quite possibly outside the thermal envelope and, if so, loses heat to the outside and very inefficient. It is also reasonable to assume that if/when the supply ducting was insulated it is much less effective at this stage of its life than when first installed. The return ductwork is located in the ceiling cavity above the bathrooms and closet space in the center of the building.

Cooling System

The station is air conditioned by three window air conditioning units permanently installed in a through-the-wall configuration. There are two located in the office side of the building and one on the other.

Temperature & Ventilating Control System

There is one thermostat installed on the office side of the police station. This operates the furnace for the whole building.

Domestic Hot Water System

A 12 gallon electric hot water tank serves the DHW demand at the Police Department.

APPENDICES

UTILITY INFORMATION

MAY 2013 - APR 2014 Billed Energy Use Table for Electricity & Fuel

Building Name	**Police Station**							
Owner	**Town of Ashby**							
Account #								
Month	Electricity KWH	Billed Demand KW	Delivery Charged $	Supplier Charged $	Electricity Total $	Oil Gallons	Oil $	**Energy $ Totals**
May 2013	3536	9.0	$357	$226	$582			**$582**
Jun	4560	10.5	$426	$321	$748			**$748**
Jul	5640	11.5	$502	$428	$929			**$929**
Aug	5142	11.0	$464	$392	$855			**$855**
Sept	4534	11.0	$409	$318	$727			**$727**
Oct	3444	9.5	$322	$233	$555			**$555**
Nov	3284	6.5	$280	$232	$512	89.2	$284	**$795**
Dec	3056	7.5	$277	$281	$558	148.6	$478	**$1,036**
Jan 2014	3233	7.5	$293	$362	$654	196.9	$649	**$1,304**
Feb	3349	7.0	$296	$258	$555	176.3	$596	**$1,150**
Mar	2993	6.5	$268	$258	$527	211.6	$662	**$1,189**
Apr 2014	2849	7.0	$264	$206	$470			**$470**
Annual (Units)	45,620		$4,158	$3,513	$7,672	822.6	$2,669	**$10,340**
Heating Season (Units)	22,208		$2,001	$1,829	$3,830	822.6	$2,669	**$6,499**
Annual ($/Unit)			$0.09	$0.08	$0.17		$3.24	
Heating Season ($/Unit)			$0.09	$0.08	$0.17		$3.24	
	Electricity MBtu					**Oil MBtu**	**Energy Use Totals (Mbtu)**	
Annual (Mbtu)	155,655					114,095	269,750	**Energy $ Totals**
Heating Season (Mbtu)	75,774					114,095	189,868	
							Totals (Mbtu/sf)	**($/sf)**
Annual (Mbtu/sf)	88.2					64.6	**152.8**	**$5.86**
Heating Season (Mbtu/sf)	42.9					64.6	**107.6**	**$3.68**
Building Name	**Police Station**						**Heated Square Footage**	**1,765**

ENCLOSURE MEASURE INFORMATION

Summary of Energy Savings					
ECM 1.1	**Insulate & Air Seal the Floor**				
	Baseline	**After ECM 1.1**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	76.2	37.7	38.48	50.5%	
Existing Seasonal System Efficiency	67%	67%			
Fuel Energy Usage (MMBtu/yr)	114.1	56.5			
Energy Savings	**% Reduction**	**Oil Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
	50.5%	823	415	$3.24	$1,348
				Total Savings	**$1,348**

Cost	Savings	Payback (yr)
$13,883	**$1,348**	**10.3**

Note:

Entire Facility Floor	1,765 sq.ft.		
0	0.0 "		
	Depth (in.)	**R-value**	**Cost ($)**
Open Cell Spray Foam	7	25	$ 11,474
	-	-	-
		Subtotal	**$ 11,474**
		Contingency	$ 1,147
		Totals	***$ 12,621***
		Advisory & Contractor Oversight	$ 1,262
		Totals	***$ 13,883***

Summary of Energy Savings					
ECM 1.2	**Construct Insulated & Sealed Crawlspace**				
	Baseline	**After ECM 1.2**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	76.2	40.2	36.00	47.2%	
Existing Seasonal System Efficiency	67%	67%			
Fuel Energy Usage (MMBtu/yr)	114.1	60.2			
Energy Savings	**% Reduction**	**Oil Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
	47.2%	823	389	$3.24	$1,261
				Total Savings	**$1,261**

Cost	Savings	Payback (yr)
$12,966	**$1,261**	**10.3**

Note:

Approx. Area of Perimeter Skirt 'Wall'	390 sq.ft.		
Two Layers of 2" Rigid Foam (2' x 8')	4.0 "		
	Depth (in.)	**R-value**	**Cost ($)**
Material for Perimeter Skirt 'Wall'	4	28	$ 1,976
Labor for Perimeter Skirt 'Wall'	-	-	$ 6,080
Material for Plastic Ground Cover	-	-	$ 380
Labor to Install Plastic Sheeting	-	-	$ 2,280
		Subtotal	**$ 10,716**
		Contingency	$ 1,072
		Totals	***$ 11,787***
		Advisory & Contractor Oversight	$ 1,179
		Totals	***$ 12,966***

ZONING & CONTROL MEASURE

Summary of Energy Savings					
ECM 2.1	**Energy Management System Controls**				
	Baseline *(after ECM 1.1)*	**After ECM 2.1**	**Savings**	**Reduction**	
Net Building Demand (MMBtu/yr)	37.7	29.9	7.80	20.7%	
Marginal System Efficiency	72%	72%			
Fuel Energy Usage (MMBtu/yr)	52.4	41.5			
Energy Savings	**% Reduction**	**Projected Oil Use**	**Gallons Saved**	**$/Unit**	**$ Saved**
	20.7%	407	84	$3.24	$273
		(after enclosure ECM)			
				Total Savings	**$273**

Cost	Savings	Payback (yr)
$1,750	**$273**	**6.4**

Note:

Zoning & Zone Control Improvement Costs	
	Cost ($)
Install New Zone Damper in Supply Ductwork of Furnace	$ 1,250
Install New Thermostat(s)	$ 500
Contingency	
Totals	***$ 1,750***
Advisory & Contractor Oversight	
Measure Total	***$ 1,750***

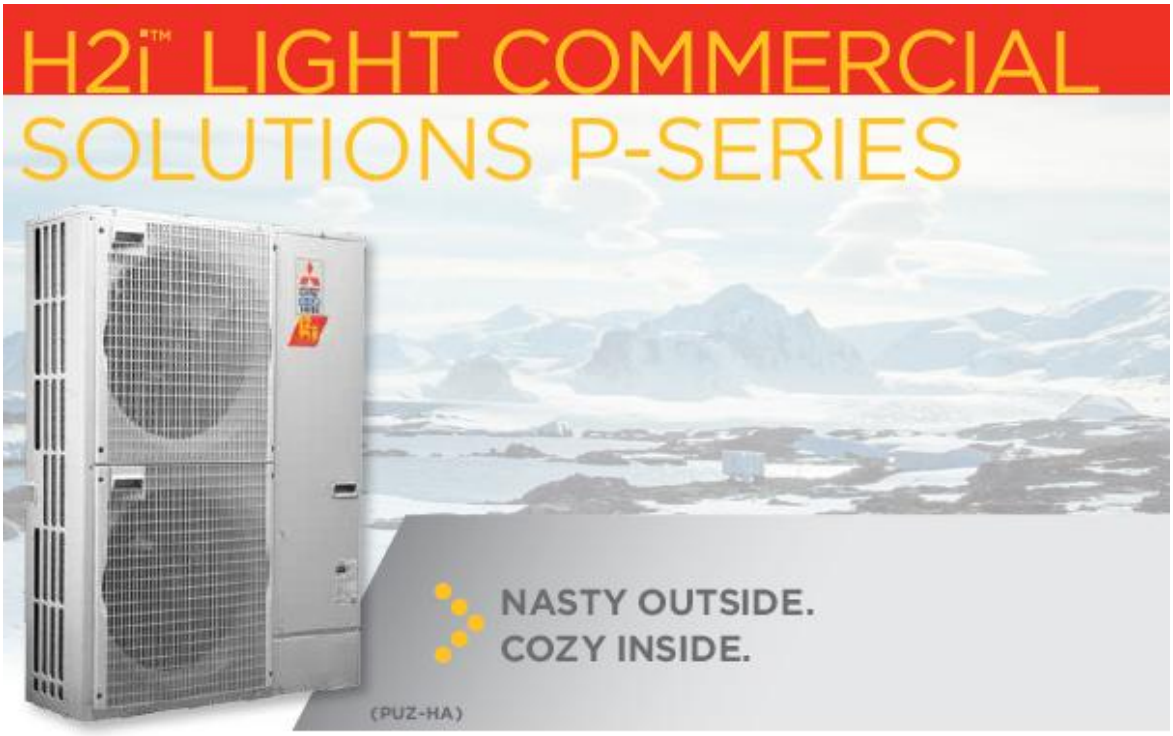
HEATING SYSTEM MEASURE

ECM 2.2	Heating with Air Source Heat Pump (ASHP)					
			Police Station			
Fuel Rate ($/gallon)					Electric Rate ($/kWh)	
$3.24	Existing Condition:			New Condition:	$0.17	
	Furnace			ASHP		
Heating Unit #	1			1	2	
Make	Rheem			Mitsubishi	Mitsubishi	
Model				PUZ-HA36NHA4	MUZ-FE18NA	
Type	Atmospheric			VRF	VRF	
Heating Medium	Air			Air	Air	
Control Mode				Variable	Variable	
Output kBtu/Hr	85		kBtu/Hr	38	18	
Steady State Eff	81%		Max. @ 5 degree O.A.T.			
Input kBtu/Hr	105		W / hr	6,318	2,978	
Seasonal Eff	67%			270%	270%	
Percentage of Load	168%			75%	35%	

Replacement-In-Kind Costs		Installed System Costs		
Furnace	$0	Mitsubishi ASHP Outdoor Unit(s) & Mitsubishi ASHP Indoor Unit(s)	$13,968	
		Installation & Electrical	$6,240	
			$20,208	*Subtotal*
		Contingency	$2,021	
			$22,229	*Subtotal*
		Contractor Oversight	$2,223	
Totals	$0	*Total:*	$24,452	

Summary of Existing Building-Related Heat Loads	Building Operating Load (kBtu/year)	Projected Fuel Usage Gallons		Fuel Cost	Peak Heating Load (kBtu/hr)	2 ASHP @ 110% of design Load
Space Heating Load	37,705	407		$1,321	51	56
Thermostat Setback Savings		-84				
Cooling Load kWh	7,200			$1,211		
			Total	$2,531		
New Condition:						
Heating kWh	3,247			$546		
Cooling Load kWh	4,824			$811		
Electric Savings kWh	-871		New Total:	$1,357		
			Savings:	$1,174		

Simple Payback Calculation	Cost	Savings	Payback
Full Cost Basis:	$24,452	$1,174	20.8
Incremental Cost Difference:	$24,452	$1,174	20.8

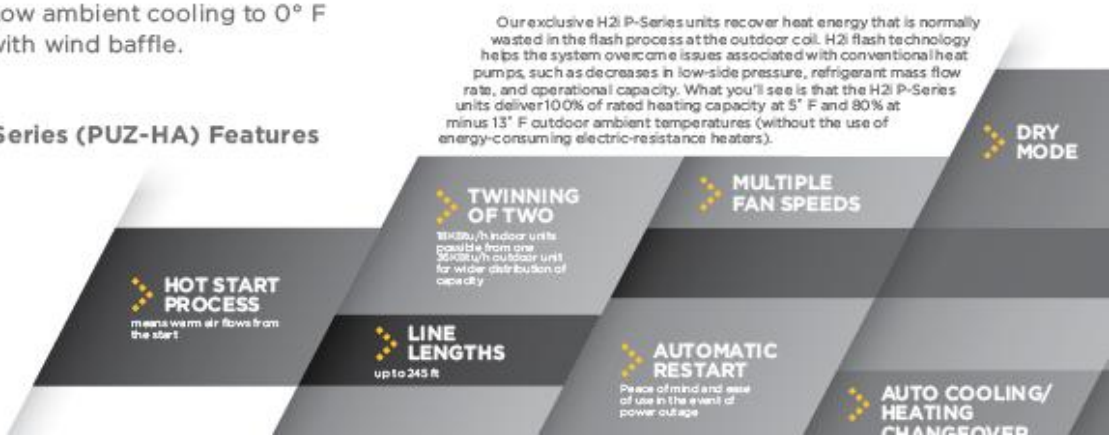


It's below freezing outside? No sweat. The P-Series Hyper-Heating INVERTER systems work to provide the perfect temperature inside. It's all possible thanks to our responsive INVERTER compressor and patented flash injection technology. Even at 0° F, air-conditioning is possible with our wind baffle accessory. These light commercial zone solutions are perfect for any business, place of worship or school in any region of the country.

- 80% Hyper-Heating performance down to -13° F outdoor ambient.
- 100% heating capacity at 5° F outdoor ambient.
- PUZ-HA30NHA4: 18,000 - 30,000 Btu/h cooling / 18,000 - 34,000 Btu/h heating.
- PUZ-HA36NHA4: 18,000 - 34,200 Btu/h cooling / 18,000 - 40,000 Btu/h heating.
- Many ENERGY STAR tax credit qualifying systems.
- Low ambient cooling to 0° F with wind baffle.

P-Series (PUZ-HA) Features

Our exclusive H2i P-Series units recover heat energy that is normally wasted in the flash process at the outdoor coil. H2i flash technology helps the system overcome issues associated with conventional heat pumps, such as decreases in low-side pressure, refrigerant mass flow rate, and operational capacity. What you'll see is that the H2i P-Series units deliver 100% of rated heating capacity at 5° F and 80% at minus 13° F outdoor ambient temperatures (without the use of energy-consuming electric-resistance heaters).



Ductwork is inefficient, costly and soon to be a thing of the past. The MSZ-FH family of Hyper-Heating INVERTER residential systems offer year-round, high-efficiency cooling and heating for bedrooms, basements, sunrooms and more. Essentially, heat pumps are now a realistic option for any home, in any climate.

M-Series (MSZ-FH) ***NEW***

- Industry-leading efficiencies.
  - MSZ-FH09NA [30.5 SEER].
  - MSZ-FH12NA [26 SEER].
  - MSZ-FH15NA [21.5 SEER].
- Hyper-Heating performance down to -13° F outdoor ambient.
- 100% heating capacity at 5° F outdoor ambient.

BASELINE HEAT BALANCE CALCULATIONS

HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-128.4
INFILTRATION LOSSES	-29.6
VENTILATION LOSSES	-9.6
SOLAR GAIN	17.4
OCCUPANT GAIN	1.9
ELECTRICAL GAIN	72.0
NET HEATING DEMAND	-76.2

Net Heating Demand (MMbtu)	/Energy Required (MMbtu)	Seasonal Efficiency %
76.2	114.1	67%

Temperature & Schedule Information

Building Name: Police Station

Total Heating Days	212	Floor SF	
Outdoor, Winter Median Temperature	35	1,765	

	Wing name	Occupied Temp.	Unoccupied Temp. Night	Unoccupied Temp. Off days	Htg System Occ. Hrs per day *	Schedule	Occ Level Heating Days
1	Office Side (Left 2/3rds)	70	70	70	24	7 days per week	212
2	Meeting/Locker Side (Right 1/3rd)	70	70	70	24	7 days per week	212

HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Office Side (Left 2/3rds)**	Ceiling 1	0.053	1,198		63
67% of the building						0
		Wall 1	0.127	991		126
						0
		Doors 1	0.580	47		27
		Doors2	0.160	11		2
		Windows 1	0.910	92		84
						0
		Floor	0.152	1,177		179
				Wing UA Total	**480.7**	
2	**Meeting/Locker Side (Right 1/3rd)**	Ceiling 1	0.053	598		32
33% of the building						0
		Wall 1	0.127	495		63
						0
		Doors 1	0.580	23		14
		Doors2	0.160	6		1
		Windows 1	0.910	46		42
						0
		Floor	0.152	588		89
				Wing UA Total	**240.0**	
				Building Total UA:	**720.8**	

CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	**Office Side (Left 2/3rds)**	481	24	212	35	86	
		481	0	212	35	0	
		481	24	0	35	0	85.6
2	**Meeting/Locker Side (Right 1/3rd)**	240	24	212	35	43	
		240	0	212	35	0	
		240	24	0	35	0	42.7
	Total UA	**721**			**Conduction Total**		**128.4**

INFILTRATION LOSSES

0.6

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	10,251	0.60	0	212	0.018	35	0.0	
		10,251	0.60	24	0	0.018	35	0.0	
	Occ.	10,251	0.60	24	212	0.018	35	19.7	19.7
2	Meeting/Locker Side (Right 1/3rd)	5,118	0.60	0	212	0.018	35	0.0	
		5,118	0.60	24	0	0.018	35	0.0	
	Occ.	5,118	0.60	24	212	0.018	35	9.8	9.8
								Infiltration Total	29.6

VENTILATION LOSSES

Zone #	Area Name	CFM	1.08	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)
1	Office Side (Left 2/3rds)	25	1.08	24	212	35	4.8
2	Meeting/Locker Side (Right 1/3rd)	25	1.08	24	212	35	4.8
		50				Ventilation Total	9.6

Enclosure ECM 1.1 Heat Balance

Enclosure ECM 1.1: HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-94.8
INFILTRATION LOSSES	-24.6
VENTILATION LOSSES	-9.6
SOLAR GAIN	17.4
OCCUPANT GAIN	1.9
ELECTRICAL GAIN	72.0
NET HEATING DEMAND	-37.7

Enclosure ECM 1.1: HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Office Side (Left 2/3rds)**	Ceiling 1	0.053	1,015		54
56% of the building						0
		Wall 1	0.127	840		106
						0
		Doors 1	0.580	40		23
		Doors2	0.160	9		2
		Windows 1	0.910	78		71
						0
		Improved Floor	0.045	997		45
				Wing UA Total	**300.7**	
2	**Meeting/Locker Side (Right 1/3rd)**	Ceiling 1	0.053	781		41
44% of the building						0
		Wall 1	0.127	647		82
						0
		Doors 1	0.580	30		18
		Doors2	0.160	7		1
		Windows 1	0.910	60		55
						0
		Improved Floor	0.045	768		35
				Wing UA Total	**231.6**	
				Building Total UA:	**532.3**	

Enclosure ECM 1.1: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	301	24	212	35	54	
		301	0	212	35	0	
		301	24	0	35	0	53.6
2	Meeting/Locker Side (Right 1/3rd)	232	24	212	35	41	
		232	0	212	35	0	
		232	24	0	35	0	41.2
	Total UA	532			Conduction Total		94.8

Enclosure ECM 1.1: INFILTRATION LOSSES

0.5

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	8,682	0.50	0	212	0.018	35	0.0	
		8,682	0.50	24	0	0.018	35	0.0	
	Occ.	8,682	0.50	24	212	0.018	35	13.9	13.9
2	Meeting/Locker Side (Right 1/3rd)	6,687	0.50	0	212	0.018	35	0.0	
		6,687	0.50	24	0	0.018	35	0.0	
	Occ.	6,687	0.50	24	212	0.018	35	10.7	10.7
							Infiltration Total		24.6

Enclosure ECM 1.2 Heat Balance

Revised Enclosure ECM 1.2: HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-97.3
INFILTRATION LOSSES	-24.6
VENTILATION LOSSES	-9.6
SOLAR GAIN	17.4
OCCUPANT GAIN	1.9
ELECTRICAL GAIN	72.0
NET HEATING DEMAND	-40.2

Revised Enclosure ECM 1.2: HEAT LOSS COEFFICIENTS

Zone #	Building Zone		U-Value (BTU/hr-sf-F)	Area (sf)		UA-Value (BTU/hr-F)
1	**Office Side (Left 2/3rds)**	Ceiling 1	0.053	1,015		54
56% of the building						0
		Wall 1	0.127	840		106
		Doors 1	0.580	40		23
		Doors2	0.160	9		2
		Windows 1	0.910	78		71
		Crawlspace 'Walls'	0.036	214		8
		Crawlspace 'Floor'	0.410	107		44
		Improved Floor			removed	0
				Wing UA Total	**307.1**	
2	**Meeting/Locker Side (Right 1/3rd)**	Ceiling 1	0.053	781		41
44% of the building						0
		Wall 1	0.127	647		82
		Doors 1	0.580	30		18
		Doors2	0.160	7		1
		Windows 1	0.910	60		55
		Crawlspace 'Walls'	0.036	176		6
		Crawlspace 'Floor'	0.410	88		36
		Improved Floor			removed	0
				Wing UA Total	**239.2**	
				Building Total UA:	**546.3**	

Revised Enclosure ECM 1.2: CONDUCTION LOSSES

#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	307	24	212	35	55	
		307	0	212	35	0	
		307	24	0	35	0	54.7
2	Meeting/Locker Side (Right 1/3rd)	239	24	212	35	43	
		239	0	212	35	0	
		239	24	0	35	0	42.6
	Total UA	546			Conduction Total		97.3

Revised Enclosure ECM 1.2: INFILTRATION LOSSES

0.5

#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	8,682	0.50	0	212	0.018	35	0.0	
		8,682	0.50	24	0	0.018	35	0.0	
	Occ.	8,682	0.50	24	212	0.018	35	13.9	13.9
2	Meeting/Locker Side (Right 1/3rd)	6,687	0.50	0	212	0.018	35	0.0	
		6,687	0.50	24	0	0.018	35	0.0	
	Occ.	6,687	0.50	24	212	0.018	35	10.7	10.7
							Infiltration Total		24.6

Zoning & Control ECM 2.1 Heat Balance

Zoning & Control ECM 2.1: HEAT BALANCE	
GAINS AND LOSSES	BTU/HEATING SEASON*1E6
CONDUCTION LOSSES	-88.6
INFILTRATION LOSSES	-23.0
VENTILATION LOSSES	-9.6
SOLAR GAIN	17.4
OCCUPANT GAIN	1.9
ELECTRICAL GAIN	72.0
NET HEATING DEMAND	-29.9

Zoning & Control ECM 2.1: Temperature & Schedule Information

Building Name: Police Station

Total Heating Days	212	Floor SF	
Outdoor, Winter Median Temperature	35	1,765	

	Wing name	Occupied Temp.	Unoccupied Temp. Night	Unoccupied Temp. Off days	Htg System Occ. Hrs per day *	Schedule	Occ Level Heating Days
1	Office Side (Left 2/3rds)	70	70	70	24	7 days per week	212
2	Meeting/Locker Side (Right 1/3rd)	70	65	60	8	7 days per week	151

Zoning & Control ECM 2.1:		CONDUCTION LOSSES					
#	Zone	UA	HOURS/ DAY	DAYS/ -	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	301	24	212	35	54	
		301	0	212	35	0	
		301	24	0	35	0	53.6
2	Meeting/Locker Side (Right 1/3rd)	232	8	151	35	10	
		232	16	151	30	17	
		232	24	61	25	8	35.1
	Total UA	532			Conduction Total		88.6

Zoning & Control ECM 2.1:		INFILTRATION LOSSES							
		0.5							
#	Zone	VOLUME	ACH	HRS/ DAY	DAYS/ YR	0.018	TEMP DIFF	LOSSES (* 1E6)	Sub Totals
1	Office Side (Left 2/3rds)	8,682	0.50	0	212	0.018	35	0.0	
		8,682	0.50	24	0	0.018	35	0.0	
	Occ.	8,682	0.50	24	212	0.018	35	13.9	13.9
2	Meeting/Locker Side (Right 1/3rd)	6,687	0.50	16	151	0.018	30	4.4	
		6,687	0.50	24	61	0.018	25	2.2	
	Occ.	6,687	0.50	8	151	0.018	35	2.5	9.1
							Infiltration Total		23.0

GREENHOUSE GAS EMISSIONS

Greenhouse Gas (GHG) Impact

Baseline Fuel Usage	Natural Gas	Propane	Oil	Electricity	MT eCO2
Space Heating & Domestic Hot Water			823		8.5

Measure #	Measure Description (RTM = Renewable Thermal Measure) (ECM = Energy Conservation Measure)	Fuel Usage After Measures: Natural Gas (MMBtu / yr)	Propane (gal / yr)	Oil (gal / yr)	Electricity (kWh / yr)	GHG Emmissions (MT eCO2)	GHG Savings (MT eCO2)	Savings As % of Baseline
ECM 1.1	Insulate & Air Seal the Floor			407		4.2	4.3	51%
OR								
ECM 1.2	Construct Insulated & Sealed Crawlspace			434		4.5	4.0	47%
ECM 2.1	Energy Management System Controls			323		3.3	0.9	10%
OR								
ECM 2.2	Heating with Air Source Heat Pump (ASHP)				3,247	1.1	3.1	37%

GHG Emmissions		
10.3	MT eCO2 / 1,000	gallons of #2 Fuel Oil
5.3	MT eCO2 / 1,000	gallons of Propane (LPG)
53.2	MT eCO2 / 1,000	MMBtu's of Natural Gas
14.1	MT eCO2 / 100	short ton of wood pellets (2,000 lbs.)
333.7	MT eCO2 / 1,000,000	kWh of electricity
per Clean Air Cool Planet Campus Carbon Calculator (2013 value)		