HARSHAW GEOTHERMAL PROJECT
HARSHAW, WISCONSIN

BY

ALEXANDER BUTKUS

MATTHEW BUTKUS

OF

GRUMMAN BUTKUS ASSOCIATES

CHAPTER/REGIONAL TECHNOLOGY AWARD - SHORT FORM

1. **Category (Check one and indicate New or Existing, if applicable)**

◯ Commercial Buildings	◯ New or ◯ Existing
Institutional Buildings:	
◯ Educational Facilities	◯ New or ◯ Existing
◯ Other Institutional	◯ New or ◯ Existing
◯ Health Care Facilities	◯ New or ◯ Existing
◯ Industrial Facilities or Processes	◯ New or ◯ Existing
◯ Public Assembly	◯ New or ◯ Existing
◉ Residential (Single and Multi-Family)	

2. **Name of building or project:** Residence

   City/State: Harshaw, Wisconsin

3. **Project Description:** HVAC Retrofit and Heat Recovery

   Project Study/Design Period: 08/2008 (Begin date (mm/yyyy)) to 07/2012 (End date (mm/yyyy))

   Percent Occupancy at time of submission: Summer home

4. **Entrant (ASHRAE member with significant role in project):**

   a. Name: Butkus (Last) Alexander (First) S. (Middle)
   Butkus Matthew S.

   Membership Number: 105624 (Alexander Butkus) / 7971230 (Matthew Butkus)

   Chapter: Illinois

   Region: VI

   b. Address (including country): Grumman/Butkus Associates, 820 Davis St, Ste 300

   Evanston (City) IL (State) 60201 (Zip) US (Country)

   c. Telephone: (O) 847-328-3555 d. Email: abutkus@grummanbutkus.com

   e. Member's Role in Project: Designer, Owner

   f. Member's Signature:

5. **Engineer of Record:** Alexander Butkus, Matthew Butkus

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.

2012 AWARD ENTRY

Illinois Chapter of ASHRAE Excellence in Engineering

Residence - Harshaw, WI

HVAC Retrofit and Heat Recovery

Grumman/Butkus Associates
Energy Efficiency Consultants and Sustainable Design Engineers
820 Davis Street, Suite 300
Evanston, IL 60201.4446
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HVAC RETROFIT AND HEAT RECOVERY
FOR
RESIDENCE
HARSHAW, WISCONSIN

Excellence in Engineering Award Entry
The Illinois Chapter of ASHRAE

October 4, 2012

Grumman/Butkus Associates
Energy Consultants and Design Engineers
820 Davis St, Ste 300
Evanston, IL 60201.4446

Alexander Butkus
Matthew Butkus

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Introduction

This project provides heating, cooling and domestic water preheating for a summer home in northern Wisconsin (approximately 45.7° north latitude). The primary HVAC unit is a water-source heat pump. The home did not have air conditioning previously. The heating portion of the system is backed up by a condensing propane furnace (the former heating unit for the house). A desuperheater integrated into the heat pump preheats domestic water for the home. The primary domestic water heater is an electric-fired, water storage unit. The ground loop consists of three, 140' to 150' deep vertical loops. System ratings are noted on the attached system diagram.

Vertical loop drilling in driveway

Energy data is summarized in the table below (the system was started in August, 2008):

Year	Summer [1] kWh	Winter [2] kWh	Annual Total kWh	Propane gals	Comment
2007/8	4,169 (Base)	1,534	5,703	397	Year before project; 8,359 HDD[3]
2009/10	3,644 (-12.6%)	4,272	7,916	0	7,410 HDD
2010/11	3,361 (-19.4%)	4,250	7,611	0	8,434 HDD
2011/12	4,156 (-0.3%)	4,016	8,172	0	7,066 HDD
2012	3,686 (-11.6%)	N/A	-	0	

(1) June through September, compared to 2007 base
(2) October through May
(3) From utility billings

Operational Observations and Set-Points

1. Heat pump satisfies load above 20F ambient.
2. Electric duct heater supplements heat pump below 20F ambient.
3. Cooling set-point 74F (occupied 8-12 weeks/year, home use increasing since system installed).
4. Part load cooling is energized at 76F, full load cooling at 78F. Full load cooling is rarely observed thus the system operates near 27.0 EER. See Energy Efficiency section.
5. Heating set-point 50F (unoccupied); 70F (about five days per year in winter).

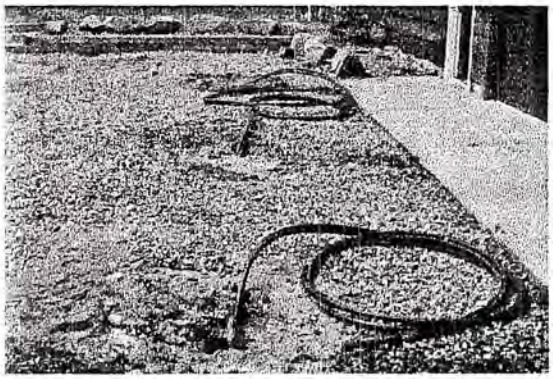
6. Observed water temperature leaving heat recovery storage tank 90F - 100F (incoming water temperature 48F, domestic hot water supply temperature 120F).

7. Ground loop maximum (summer) and minimum(winter) temperatures are noted below:

	Supply	Return
Winter	30.2F	25.3F
Summer	73.8F	77.7F

Energy Efficiency

The air conditioning system operates at an EER of 27.0 (0.44 kW/ton) part load and 18.2 (0.66 kW/ton) at full load.



Vertical ground loops before header installed

Summer energy use has dropped while home usage has increased, from 4,169 kWh (2007) to 3,644 kWh (2009), 3,361 kWh (2010), 4,156 kWh (2011) and 3,686 kWh (2012). These numbers also include the electrical usage of the heat pump operating as an air conditioner from 2009-2012. There was no air conditioning in 2007. These are percentage reductions of 0.3% to 19.4% compared to base year of 2007. These reductions in energy use are due to lower domestic hot water energy use due to heat recovery.

Winter energy use has resulted in a reduction in propane use of 397 gallons as the propane furnace no longer operates as the main source of heat. The table below compares winter heat pump use to estimated propane use, had a propane furnace been the main source of heating. Heat pump overall COP is estimated below:

	2009/10	2010/11	2011/12
Winter, kWh	4,272	4,250	4,016
Fan/Occupant Use, kWh(1)	1,534	1,534	1,534
Heating, kWh	2,738	2,716	2,482
Heat Pump MBtus kWh *3413	9,345	9,270	8,471
Propane MBtus(2) gallons * 92500 * 0.9	29,653	33,350	27,938
Ratio Propane MBtu/ Heat Pump MBtu	3.17	3.60	3.30

(1) 2007 Winter energy use

(2) 2007 propane use, 397 gallons adjusted by each winter's HDD

Indoor Air Quality

The heat pump uses a MERV 7 pleated filter. The fan operates continuously in summer to equalize temperatures in the house. The continuous circulation at a rate of about 1.5 AC/hour improves air quality. Humidity is controlled with the addition of the heat pump for air conditioning.

Innovation

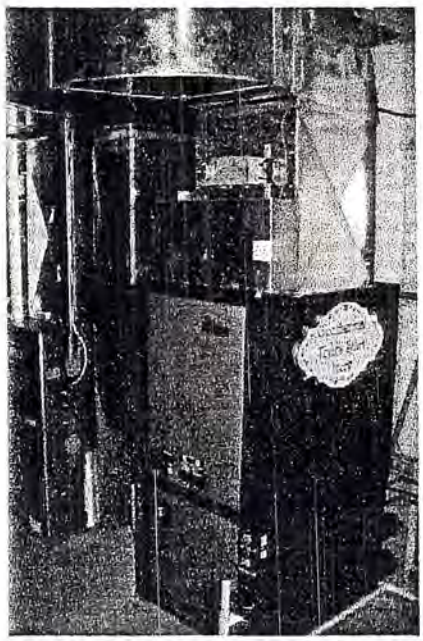
The system is one of a growing number of water-source heat pumps. The recovery of heat to reduce domestic water energy use is a simple system addition with excellent energy savings results.

Operation and Maintenance

Air filters are changed seasonally. Pumps and fan motors are permanently lubricated.

Cost Effectiveness

The out-of-pocket costs for the system were $17,500 less a $2,000 tax credit or $15,500.



Water source heat pump and propane furnace in background

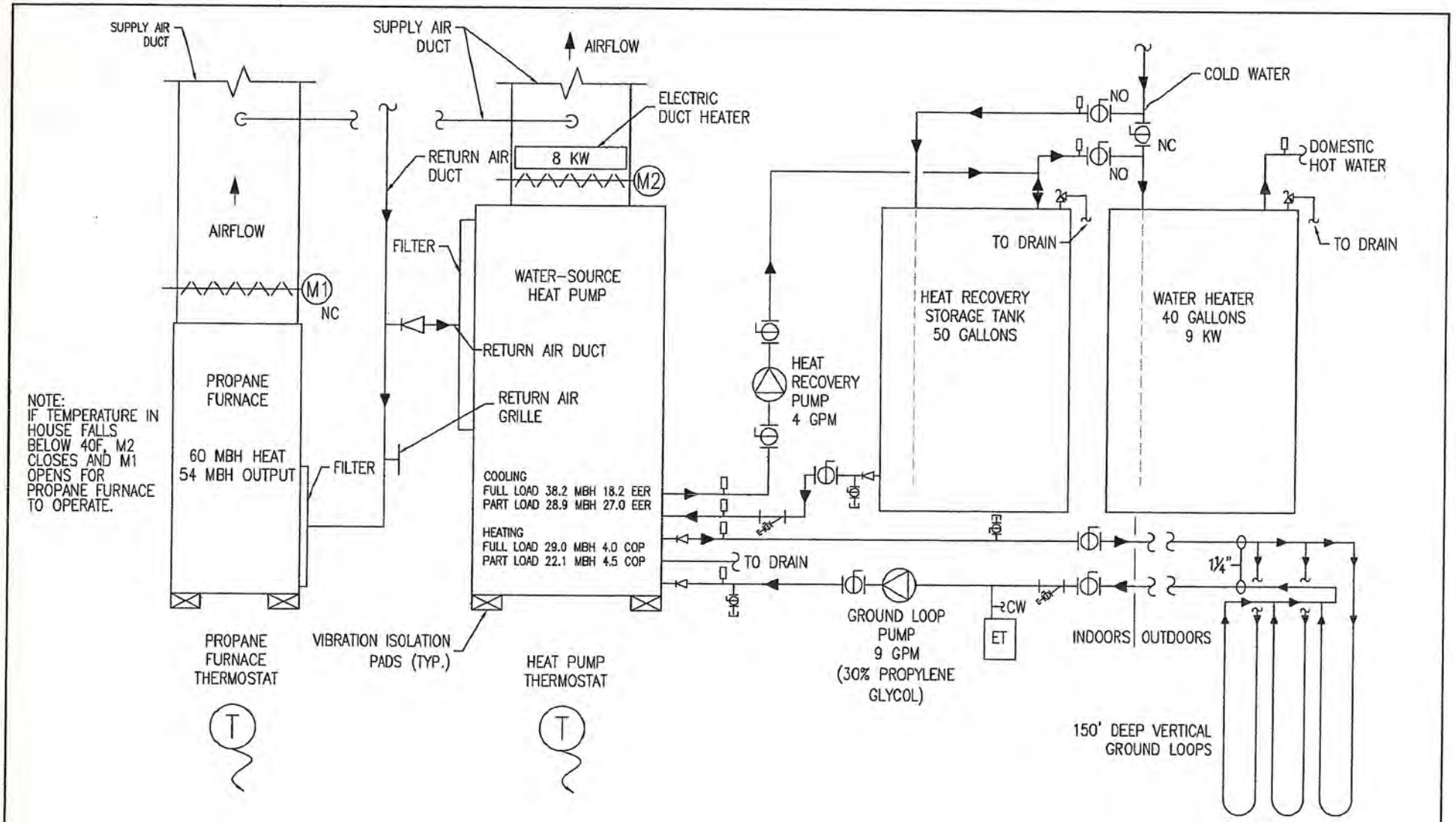
Annual energy savings for the systems as operated (not including an adjustment for air conditioning energy use, none in 2007 and fully air conditioned 2009 to date – a major factor) is about $450 (34 year payback).

However, a spreadsheet projection of energy use if the home was occupied year-round results in a payback of five to nine years depending on utility rate assumptions.

The application of this system should be in new construction. The primary incremental cost for new construction is the ground loop, heat recovery tank and slightly higher equipment costs. This cost of $10,000, if included in a mortgage, would increase the monthly mortgage cost on the order of $50. Every home with such a system should be cash flow positive in the first month of operation – with air conditioning operating at 18-27 EER and an efficient heating heat pump.

Environmental Impact

Propane reduction (2007):	397 gallons	5,022 lbs CO_2/year
Electrical use increase: (including air conditioning)	2,200 kWh (approximate 3 year average)	3,564 lbs CO_2/year
Net Savings:		1,458 lbs CO_2/year



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ISSUES & REVISIONS		
NO.	DESCRIPTION	DATE

HEAT PUMP SCHEMATIC

Residence

Harshaw, WI 54529

DATE	10/8/12
DRAWN	MSB
APPROVED	ASB
SCALE	NONE
PROJECT NO.	ASHRAE

SK 1