Plumas-Sierra Rural Electric Cooperative (PSREC) Engineering Evaluation of GeoExchange Program

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1. SUMMARY

The purpose of this report is to document the engineering evaluation of the Ground Source Heat Pump (GSHP) GeoExchange program, conducted by Efficiency Services Group (ESG) at the request of the Plumas-Sierra Rural Electric Cooperative (PSREC). The intent is to provide an energy use comparison between conventional HVAC and Ground Source Heat Pump systems. The analysis was developed by modeling various scenarios using eQuest version 3.63 energy modeling software (http://www.doe2.com/eQuest). This software was chosen for its ability to model both vertical and horizontal GSHP configurations. In addition to eQuest, GSHP-CALC software (http://www.geokiss.com) was utilized to validate well designs for intended load profiles. Three typical homes were modeled, representing a range of home size, at 1200, 2000 and 3000 square feet. Each home was modeled with five types of space conditioning, yielding a total of fifteen scenarios. These residence sizes correspond to HVAC loads of 3, 4, and 5 tons respectively, which reflect the majority of actual GSHP installations in the PSREC district.

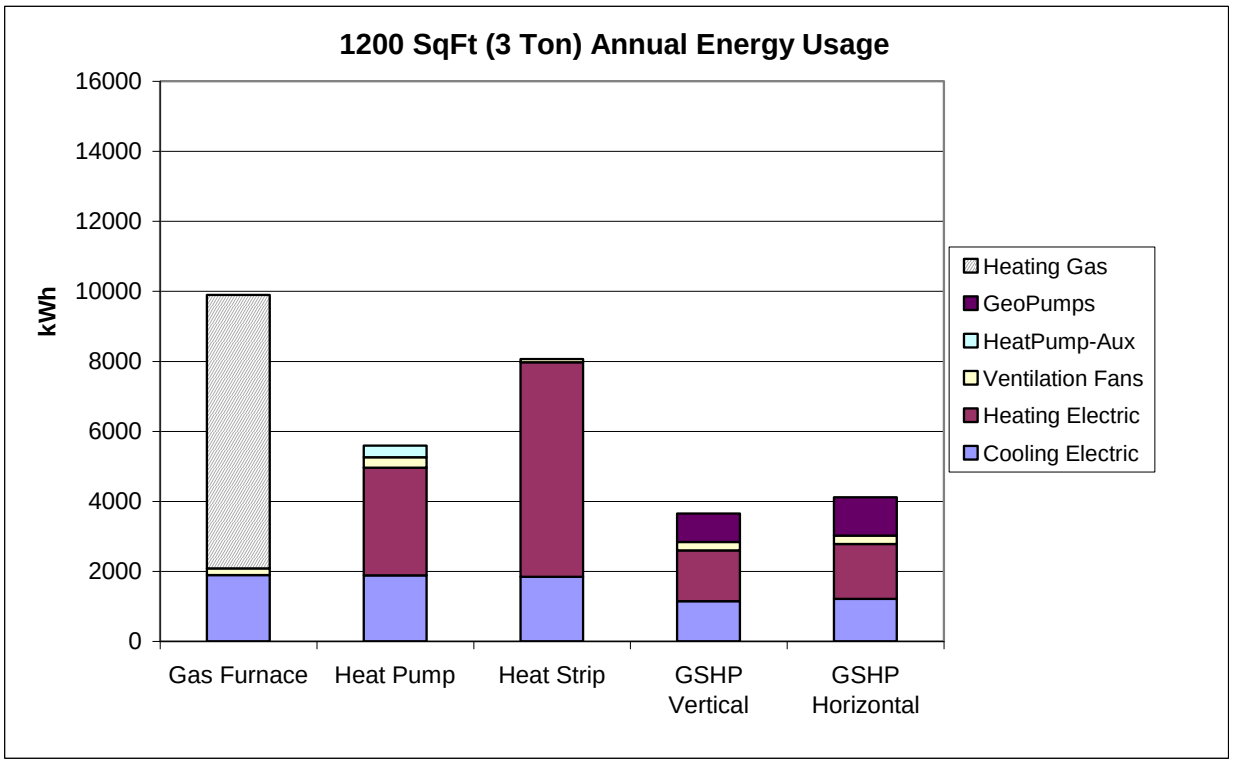
Table 1 – Summary of Residential Models

	Model Name	Description
1200 SqFt. Residence 3 Tons AC 19.4 MBH Heat (see page 10 for details)	Plumas 1200 GasFurn	Packaged AC w/ Gas Furnace
	Plumas 1200 HeatPump	Packaged Air-Side Heat-Pump
	Plumas 1200 HeatStrip	Packaged AC w/ Electric Base-Board Heat
	Plumas 1200 GSHP Vert	GSHP with Vertical Wells
	Plumas 1200 GSHP Horiz	GSHP with Horizontal Wells
2000 SqFt. Residence 4 Tons AC 26.9 MBH Heat (see page 14 for details)	Plumas 2000 GasFurn	Packaged AC w/ Gas Furnace
	Plumas 2000 HeatPump	Packaged Air-Side Heat-Pump
	Plumas 2000 HeatStrip	Packaged AC w/ Electric Base-Board Heat
	Plumas 2000 GSHP Vert	GSHP with Vertical Wells
	Plumas 2000 GSHP Horiz	GSHP with Horizontal Wells
3000 SqFt. Residence 5 Tons AC 30.7 MBH Heat (see page 18 for details)	Plumas 3000 GasFurn	Packaged AC w/ Gas Furnace
	Plumas 3000 HeatPump	Packaged Air-Side Heat-Pump
	Plumas 3000 HeatStrip	Packaged AC w/ Electric Base-Board Heat
	Plumas 3000 GSHP Vert	GSHP with Vertical Wells
	Plumas 3000 GSHP Horiz	GSHP with Horizontal Wells

The data from the resulting models shows that a Vertical GSHP provides the most efficient means to heat a residence. This unit is almost twice as efficient as a Base Board Electrical System (BBES), which is the most common source of heating in the PSREC district (BBES information provided by PSREC).

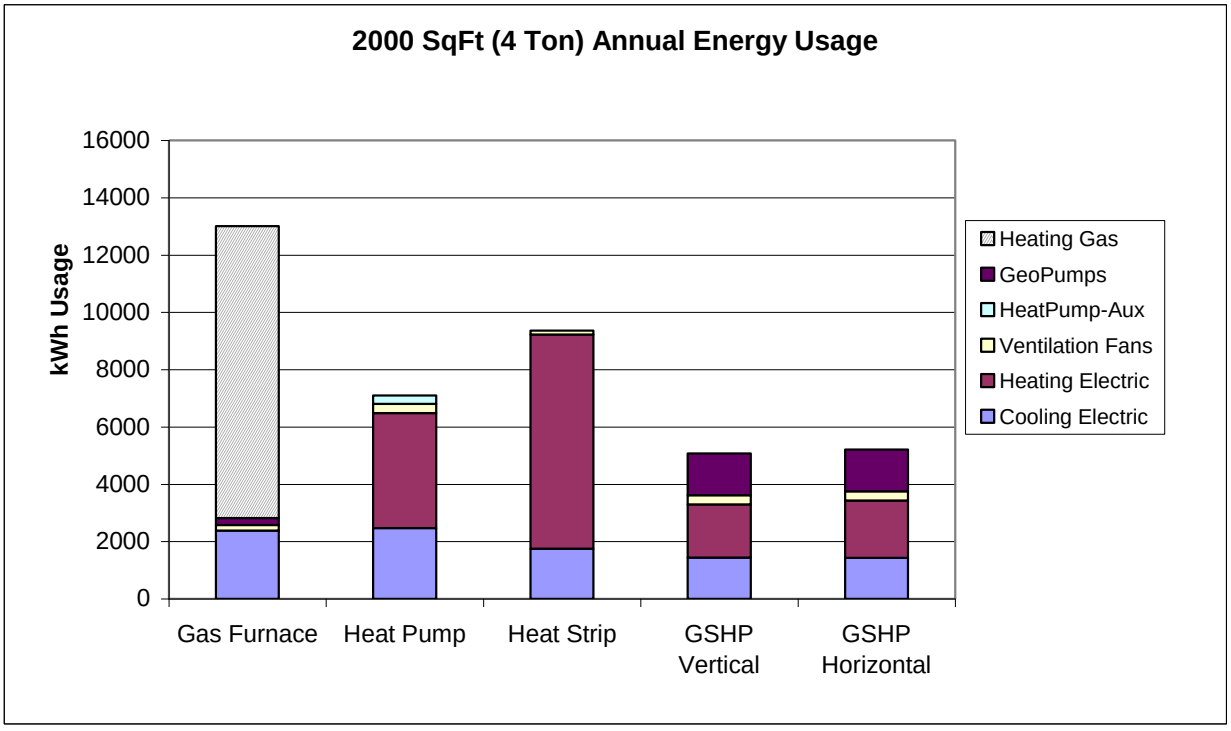
Charts 1 through 3 summarize the annual energy usage results from this study.

Chart 1 – Residental Model 1200 SqFt Energy Usage



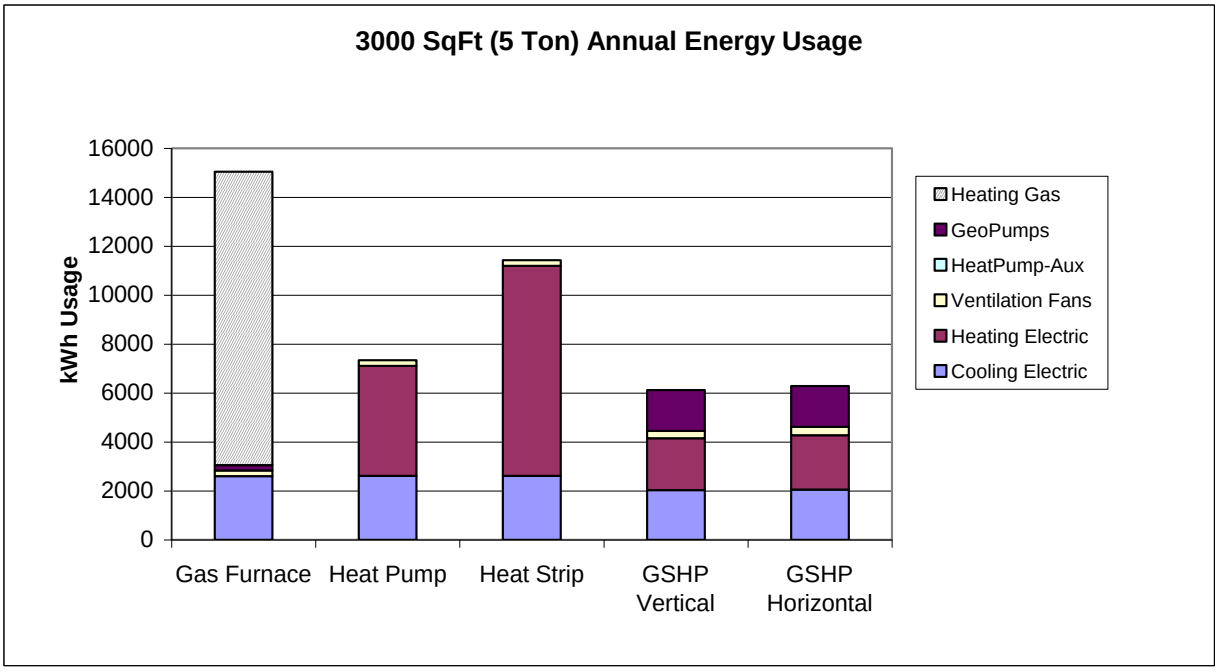
Note: Gas was converted into kWh using a gas conversion factor of: 1 Gas BTU = 0.000293 KWh

Chart 2 – Residential Model 2000 SqFt Energy Usage



Note: Gas was converted into kWh using a gas conversion factor of: 1 Gas BTU = 0.000293 KWh

Chart 3 – Residential Model 3000 SqFt Energy Usage



Note: Gas was converted into kWh using a gas conversion factor of: 1 Gas BTU = 0.000293 KWh

Summary of Results

The annual Consumption (kWh) and Demand (kW) reduction from changing from a BBES to a Horizontal GSHP system are as follows:

Residence Reduction Estimate			
HVAC Tons	**SqFt**	**Annual Consumption Reduction (kWh / Yr)**	**Demand Reduction (kW)**
3Ton	1200	4169	0.71
4Ton	2000	4370	1.25
5Ton	3000	5370	0.51
per Ton		**1185**	**0.216**

This data differs from GSHP data found in KEMA's "Measure Quantification Methodology Statewide Savings and Cost report". The KEMA data for Climate Zone 16 with base-board heat strip is separated into both Cooling and Heating:

KEMA Data				
	kWh / Yr Heating	kW Demand	kWh / Yr Cooling	Total kWh /Yr Reduction
Average per Residence	969	0.28	150	1119

One possible explanation for this difference is that climate zone 16 encompasses a very large area. By critical review of local weather data, significant differences in heating and cooling days are apparent, and these differences will result in different annual consumption and peak demand results.

2. PROGRAM DESCRIPTION

GeoExchange

The GeoExchange program from PSREC provides a 30-year interest free (non-transferable) lease on exterior Ground loops for both new construction and retrofits. The fee schedule is based on HVAC tonnage and loop configuration (Horizontal or Vertical). In addition, a free 85-gallon Marathon water heater ($800 value) or a $500 rebate will be issued upon the closing of the geo loop lease.

Horizontal Loop
Normal Conditions
Maximum Lease Amount $14,994

Horizontal Well Configuration	
Exchanger Size	Monthly Price
3 ton	$12.45
4 ton	$14.95
5 ton	$17.95
6 ton	$20.45
7 ton	$22.95
8 ton	$25.95
9 ton	$28.95
10 ton	$31.95

Vertical Loop
Normal Conditions
Maximum Lease Amount $14,994

Vertical Well Configuration	
Exchanger Size	Monthly Price
3 ton	$24.95
4 ton	$29.95
5 ton	$36.95
6 ton	$41.65
7 – 10 ton	Requires Review

The following limitations are set forth for service availability:
- Customer must utilize a PSREC certified contractor
- Residence must be owner-occupied, no leases offered for developer homes
- Owners must maintain a valid and continuing homeowner's insurance policy
- PSREC cannot guarantee that all building sites, due to soil, rocky or cobble conditions and county requirements will be able to utilize GeoExchange technology

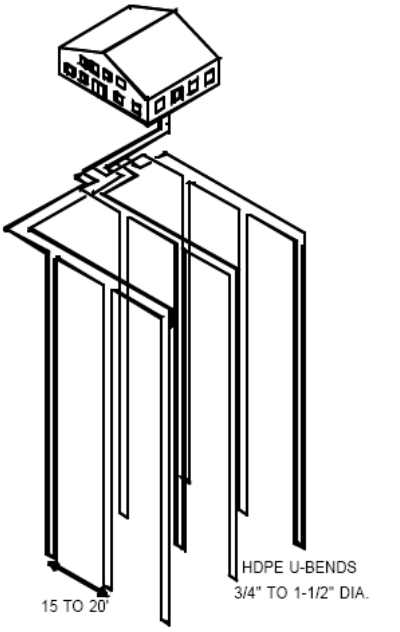
3. ANALYSIS

GSHP Background

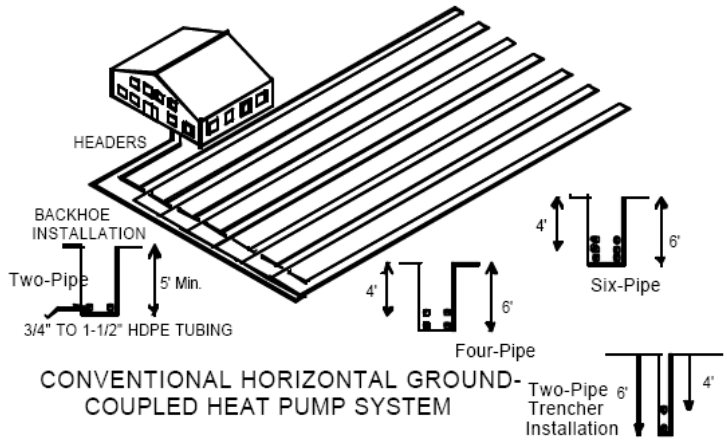
GSHP systems are composed of two (2) major components. The first is the compressor and air-side system. This component provides the heat extraction/rejection modes through refrigerant cycles and air handling via a forced air fan. The second is the liquid-side system. This system is composed of fluid pumps, fluid transport piping, and in-ground (earth) heat exchange. The in-ground heat exchange system is typically closed loop, meaning the system doesn't rely on water to be exchange outside of the system. These in-ground systems are separated into two differing categories; vertical and horizontal wells. The horizontal wells are either straight pipe or slinky installations (See Examples on page 6 for more detail). The key to the in-ground heat exchange is to develop a long liquid path over a large area to create an efficient and thermally sustainable heat exchanger.

Examples - GEO Exchange systems

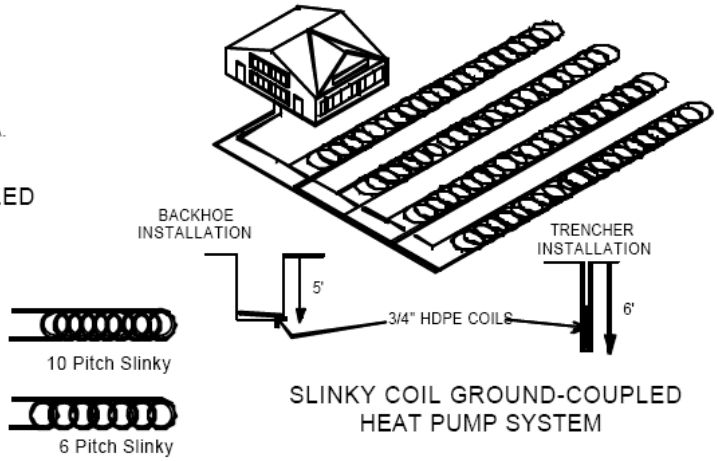
(Pictures fromhttp://www.geokiss.com/res-design/GSHPDesignRec2.pdf)



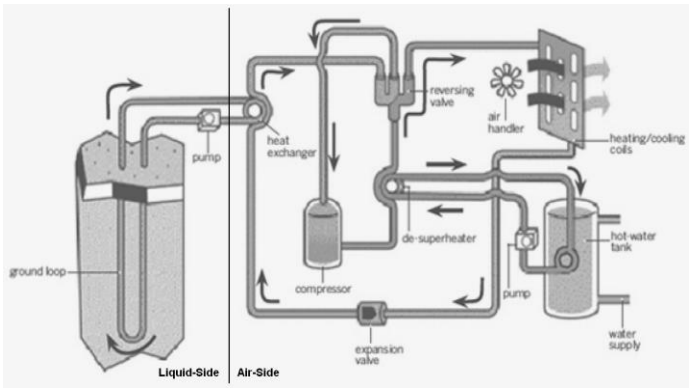
VERTICAL GROUND-COUPLED
HEAT PUMP SYSTEM
250 – 300ft. depth typical



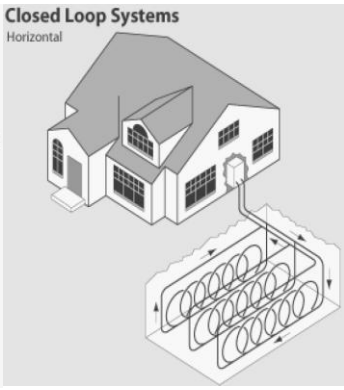
CONVENTIONAL HORIZONTAL GROUND-
COUPLED HEAT PUMP SYSTEM



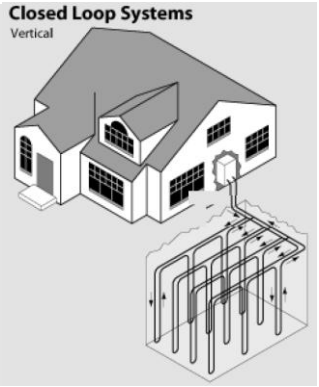
SLINKY COIL GROUND-COUPLED
HEAT PUMP SYSTEM



GHSP System



Horizontal Slinky



Vertical Well

Weather and Climate

Period of study

Starting Date	Ending Date	Number of Days
1 JAN 2009	31 DEC 2009	365

Site characteristic data

Weather Station	Latitude (deg)	Longitude (deg)	Altitude (ft)	Time Zone	Azimuth (deg)
CZ16RV2 WYEC2	41.3	122.3	4850	PST	0.0

Temperature - Weather

Cooling Load Design - Jul 26 4 PM				Heating Load Design – Jan 21 7AM			
Temp DB/WB	Solar Rad	Wind Speed	Cloud 0(clear)-10	Temp DB/WB	Solar Rad	Wind Speed	Cloud 0(clear)-10
92.F/63.F	290 BTU/H.SQFT	3.9 KTS	1	-9.F/-10.F	290 BTU/H.SQFT	2.6 KTS	5

Zone and Equipment

HVAC Zone Setting

Occupied		Unoccupied		Supply	
Cool	Heat	Cool	Heat	Cooling	Heating
78	68	78	68	55	120

Schedule

Mon	Tue	Wen	Thu	Fri	Sat	Sun	Hol
On 24 hrs.	On 24 hrs.	On 24 hrs.	On 24 hrs.	On 24 hrs.	On 24 hrs.	On 24 hrs.	On 24 hrs.

Equipment

Unit Information	Size	Cooling Efficiency	Heating Efficiency
Gas Furnace	3,4,5 Tons	13 SEER	.8 Efficiency
AC Only w/Electric Base board	3,4,5 Tons	13 SEER	Auto-Size 125% of demand
Air Heat Pump	3,4,5 Tons	13 SEER	COP 3
Vertical GSHP	3,4,5 Tons	EER 15.5	COP 3.51
Horizontal GSHP	3,4,5 Tons	EER 14.5	COP 3.32

GSHP GeoExchange Characteristics

- **Vertical Well**

Flow	Loop Temp	Loop Head	Delta T	Pump	Pipe	Ground Temp
3.0 GPM/Ton	40F / 80F	62 FT HD	10F	High Eff.	1” Dia. SDR-11	55F

Configuration	Wells/Ton	Depth	Spacing	Hole Dia	Pipe Spacing	Temp Swing
3x1, 4x1, 5x1	1	250 FT	20FT	5 inch	2 inch	5F

Fluid	Ground	Grout	Diffusivity	Pipe	Conductivity
Water	Andesite	20%B, 40%Q	0.036 FT2/H	0.23 BTU/H.FT.^{o}F	1.27 BTU/H.FT.^{o}F

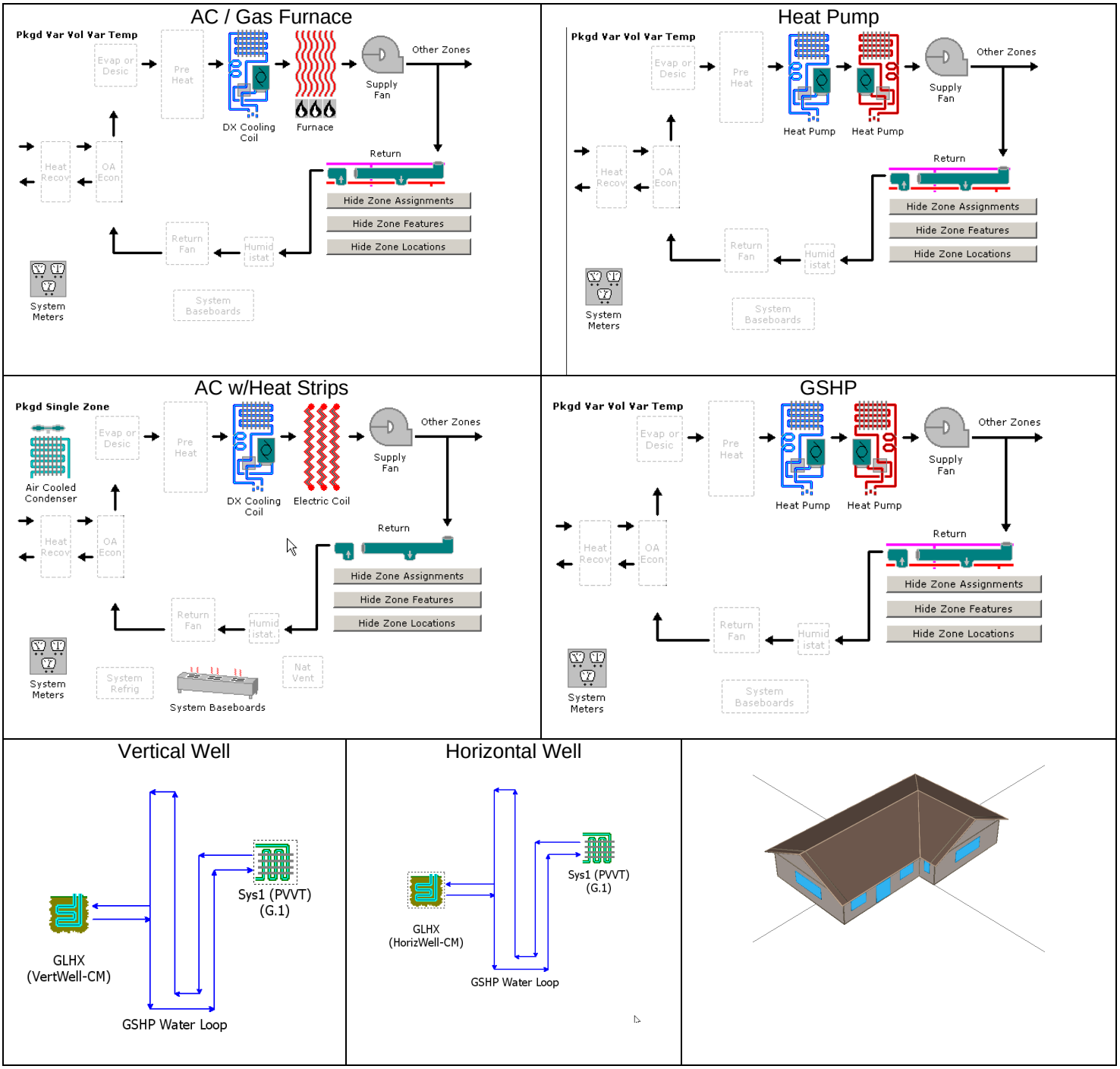
- **Horizontal Well**

Flow	Loop Temp	Loop Head	Delta T	Pump	Pipe	Ground Temp
3.0 GPM/Ton	35F / 85F	82 FT HD	10F	High Eff.	1” Dia. SDR-11	55F

Configuration	Trench/Ton	Length	Spacing	Depth	Pitch	Pipe FT/PP
Slinky - Backhoe	1	115 FT	25FT	5 FT	12 Inch	10FT per Foot

Fluid	Ground	Grout	Diffusivity	Pipe	Conductivity
Water	Andesite	Back Fill	0.036 FT2/H	0.23 BTU/H.FT.^{o}F	1.27 BTU/H.FT.^{o}F

eQuest Diagrams



eQuest 1200 SqFt. (3 Ton Model) Data Analysis

Thermal Energy Load

(Note that eQuest considers Heating Load to be Negative and Cooling to be Positive)

eQuest House Load (3-ton, 1200 sq.ft.)				
	COOLING ENERGY (MBTU)	**MAXIMUM COOLING LOAD (KBTU/HR)**	**HEATING ENERGY (MBTU)**	**MAXIMUM HEATING LOAD (KBTU/HR)**
JAN	0.30	10.68	-4.03	-15.49
FEB	0.59	13.94	-3.40	-15.03
MAR	1.05	14.61	-2.21	-12.48
APR	1.68	16.34	-1.64	-11.23
MAY	2.73	16.06	-0.51	-8.84
JUN	3.62	22.62	-0.18	-7.60
JUL	5.30	21.91	-0.06	-4.64
AUG	4.53	21.44	-0.16	-5.77
SEP	3.22	19.18	-0.42	-7.99
OCT	1.91	18.62	-1.87	-10.93
NOV	0.46	12.14	-3.15	-12.98
DEC	0.20	8.34	-4.50	-14.94
TOTAL	**25.59**		**-22.11**	
MAX		**22.62**		**-15.49**

Utility Energy Load

Gas Furnace	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling (kWh)	0	0	82	130	213	283	421	364	250	148	0	0	1890
Ventilation Fans (kWh)	14	14	12	14	15	18	26	23	17	15	12	15	194
Gas Consumption (Therms)**	48	41	27	21	7	0	0	0	6	24	39	54	267

Heat Pump (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	80	130	210	280	420	360	250	150	0	0	1880
Space Heating	560	480	310	230	80	0	0	0	70	260	450	640	3080
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	30	220
Ventilation Fans	30	30	20	20	20	20	30	20	20	20	30	40	300

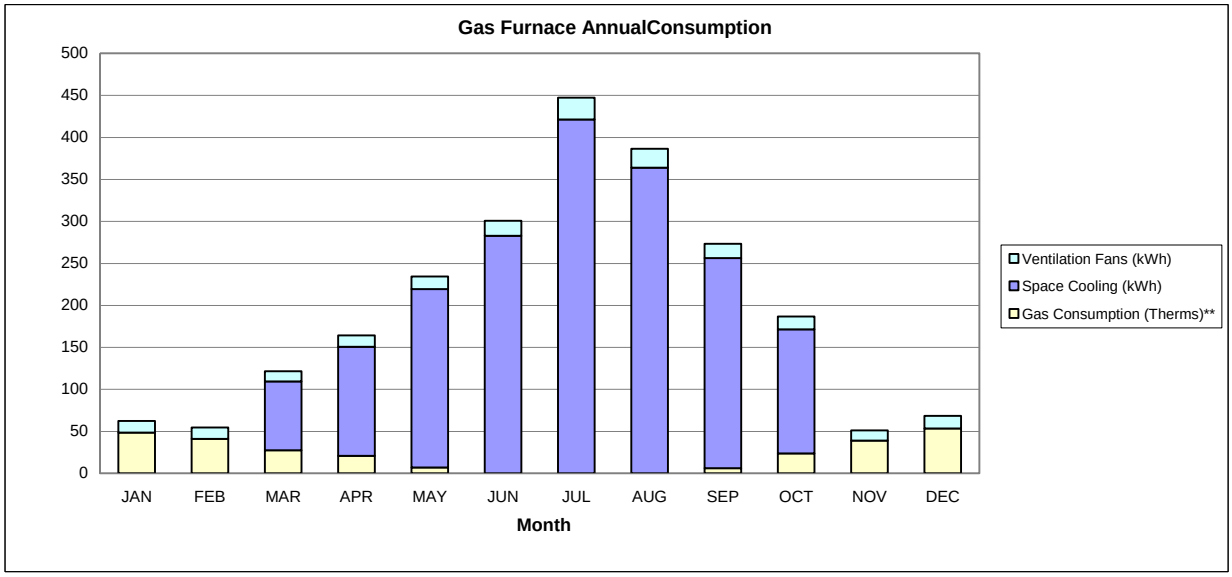
Heat Strip (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	80	120	200	270	410	370	250	140	0	0	1840
Space Heating	1130	960	620	470	150	0	0	0	120	530	890	1260	6130
Ventilation Fans	0	0	0	10	10	10	20	20	10	10	0	0	90

GSHP Vertical (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	47	76	125	167	254	224	157	91	0	0	1141
Space Heating	269	228	149	111	35	0	0	0	29	124	210	299	1452
Pumps & Aux.	108	95	75	67	39	31	36	37	40	75	98	112	814
Ventilation Fans	22	21	17	17	16	18	26	24	18	19	18	24	240

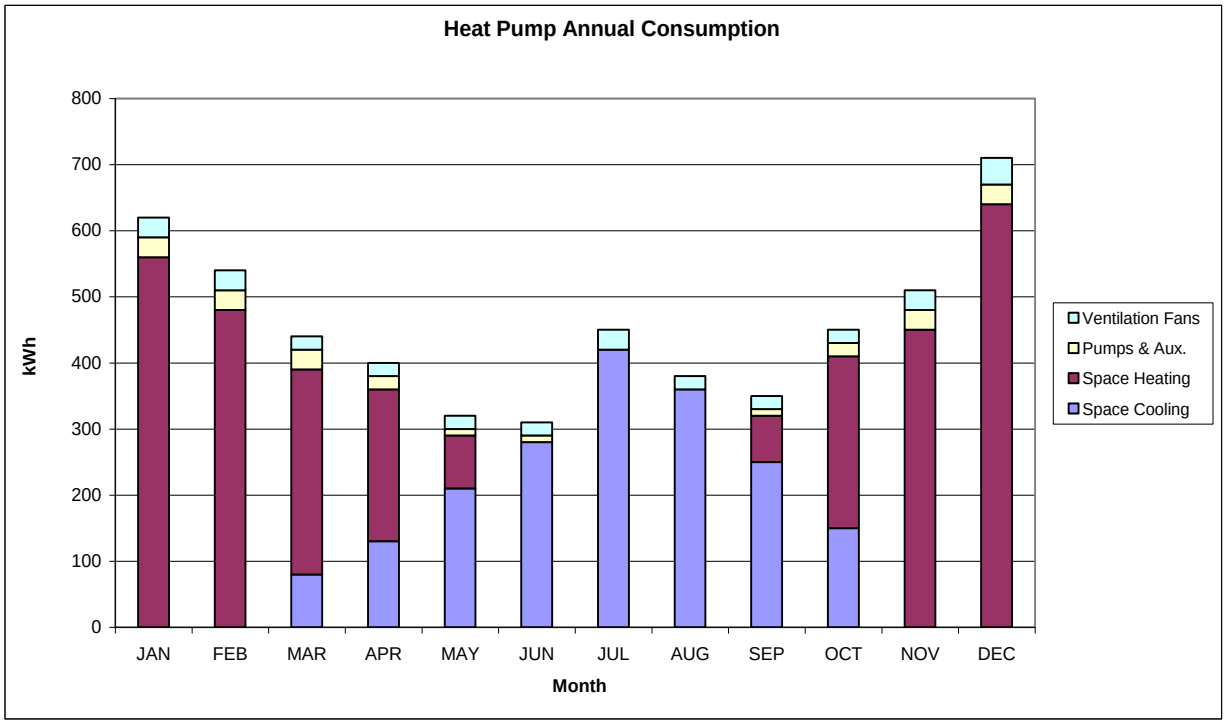
GSHP Horizontal (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	50	80	130	181	276	239	164	94	0	0	1213
Space Heating	293	248	161	119	37	0	0	0	30	131	224	323	1565
Pumps & Aux.	145	128	100	90	53	42	50	50	54	100	131	149	1089
Ventilation Fans	23	21	17	17	17	19	27	24	19	19	18	24	244

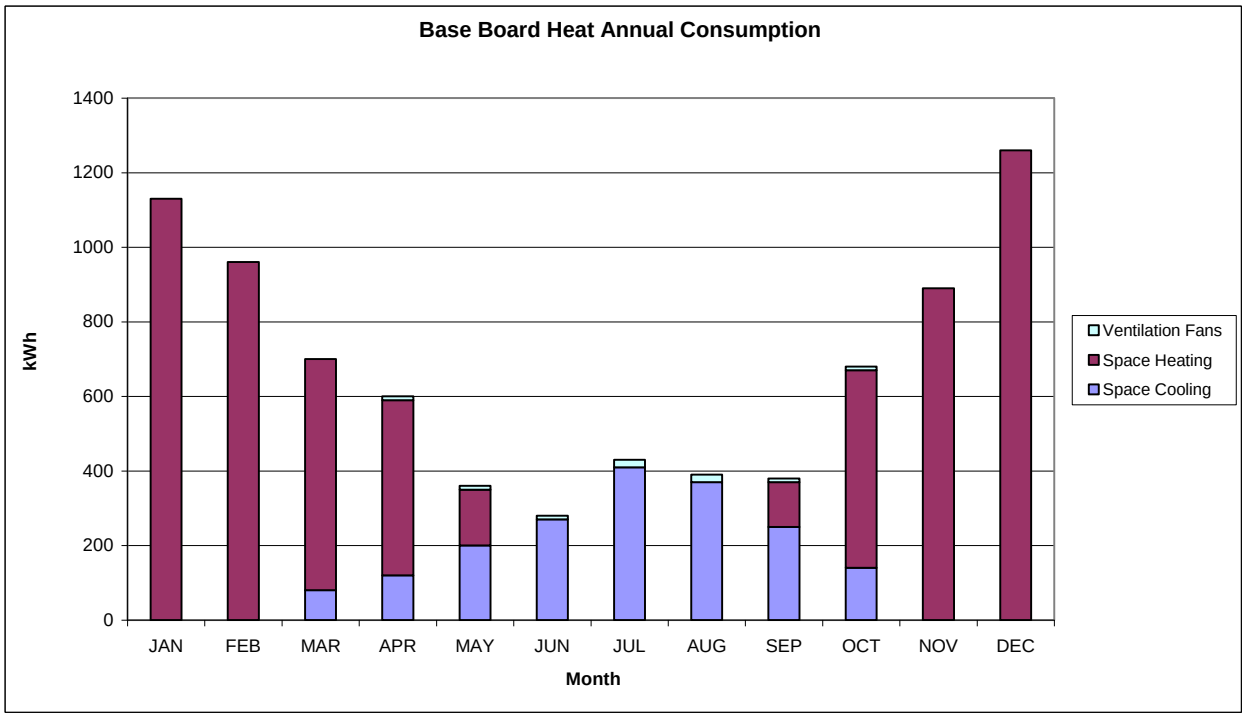
Note: **This value is stated in Propane Gas, as that is the units used by eQuest.

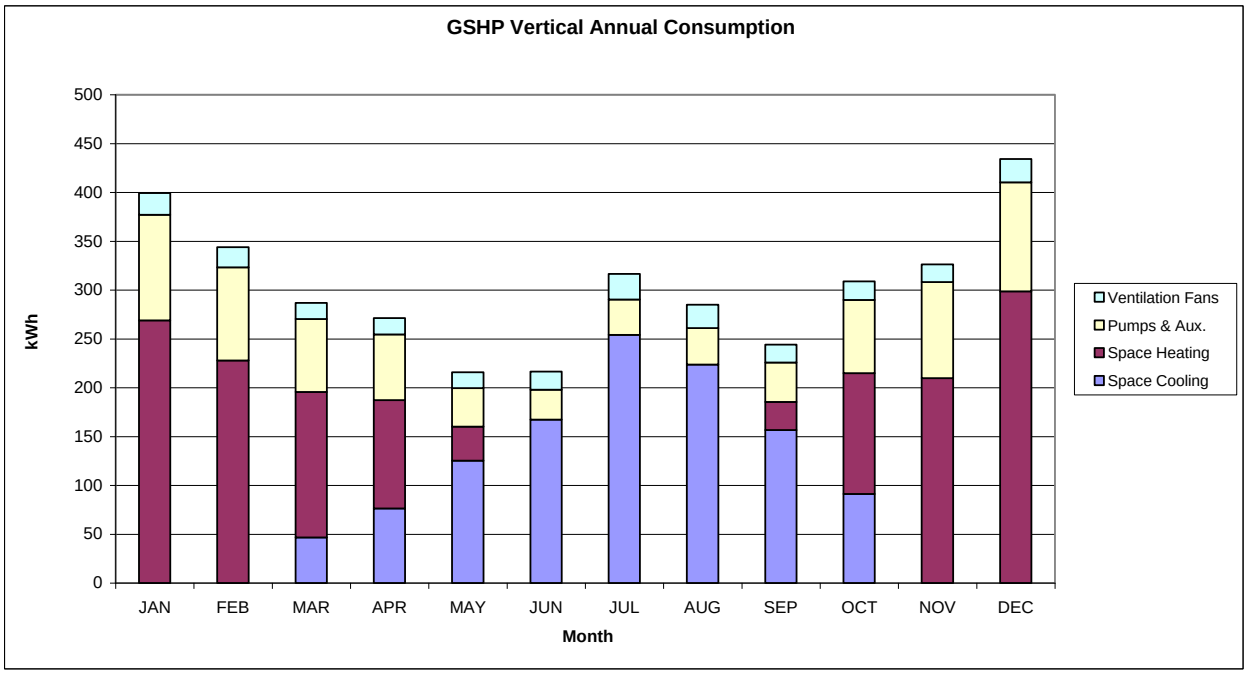
Utility Load Chart

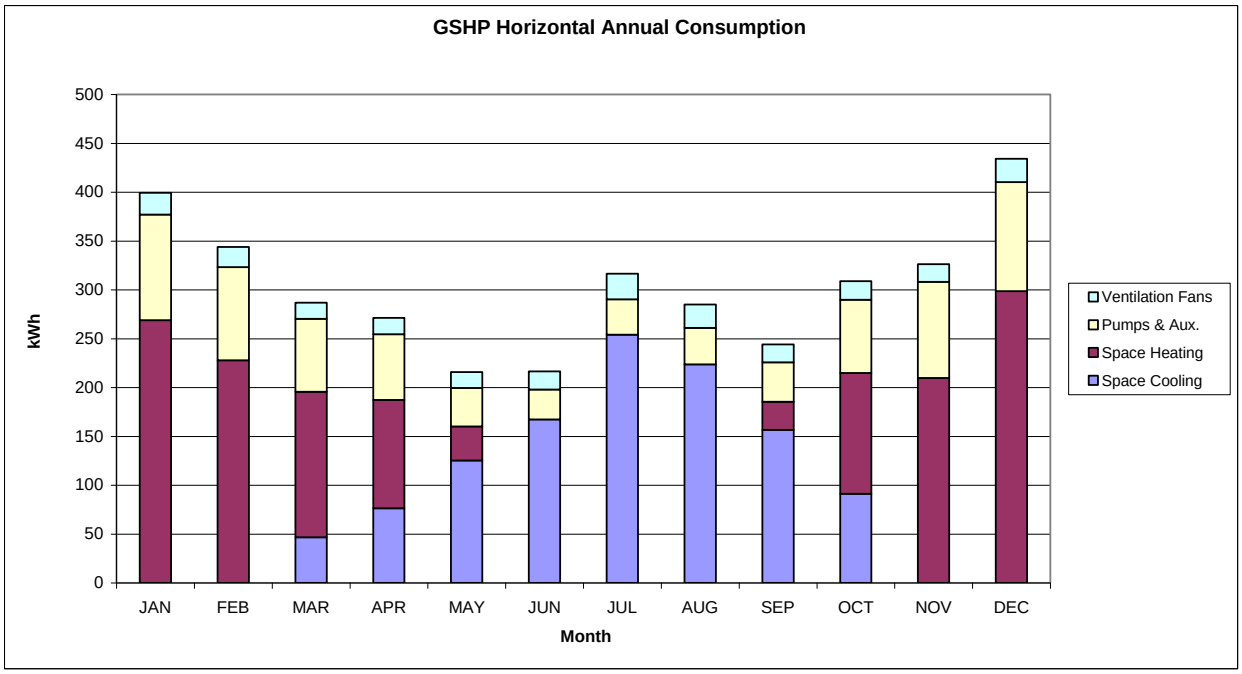


Note: **This value is stated in Propane Gas, as that is the units used by eQuest. Converted to kWh in our analysis




Base Board Heat Annual Consumption
1400
1200
1000
800
600
400
200
0
kWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Ventilation Fans
Space Heating
Space Cooling


GSHP Vertical Annual Consumption
500
450
400
350
300
250
200
150
100
50
0
kWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling


GSHP Horizontal Annual Consumption
kWh
500
450
400
350
300
250
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling

eQuest 2000 SqFt. (4 Ton Model) Data Analysis

Thermal Energy Load

(Note that eQuest considers Heating Load to be Negative and Cooling to be Positive)

eQuest House Load (4-ton, 2000 sq.ft.)				
	COOLING ENERGY (MBTU)	**MAXIMUM COOLING LOAD (KBTU/HR)**	**HEATING ENERGY (MBTU)**	**MAXIMUM HEATING LOAD (KBTU/HR)**
JAN	0.34	14.89	-5.32	-21.49
FEB	0.75	19.87	-4.47	-20.81
MAR	1.29	19.47	-2.80	-17.28
APR	2.09	22.27	-1.96	-15.54
MAY	3.69	21.90	-0.49	-11.96
JUN	5.22	31.46	-0.13	-9.80
JUL	7.71	28.99	-0.03	-4.94
AUG	6.52	29.84	-0.06	-7.09
SEP	4.65	27.48	-0.29	-10.60
OCT	2.70	26.78	-2.16	-15.01
NOV	0.59	17.32	-4.00	-18.03
DEC	0.23	11.69	-6.05	-20.85
TOTAL	**35.79**		**-27.75**	
MAX		**31.46**		**-21.49**

Utility Energy Load

Gas Furnace	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling (kWh)	0	0	100	160	260	350	530	460	320	200	0	0	2380
Ventilation Fans (kWh)	10	10	10	10	20	20	30	30	20	20	10	10	200
Gas Consumption (Therms)**	64	54	36	27	9	0	0	0	7	30	51	70	348

Heat Pump (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	100	160	270	370	560	480	330	200	0	0	2470
Space Heating	740	630	410	300	100	0	0	0	80	330	590	830	4010
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	30	220
Ventilation Fans	40	30	20	20	20	20	30	30	20	20	30	40	320

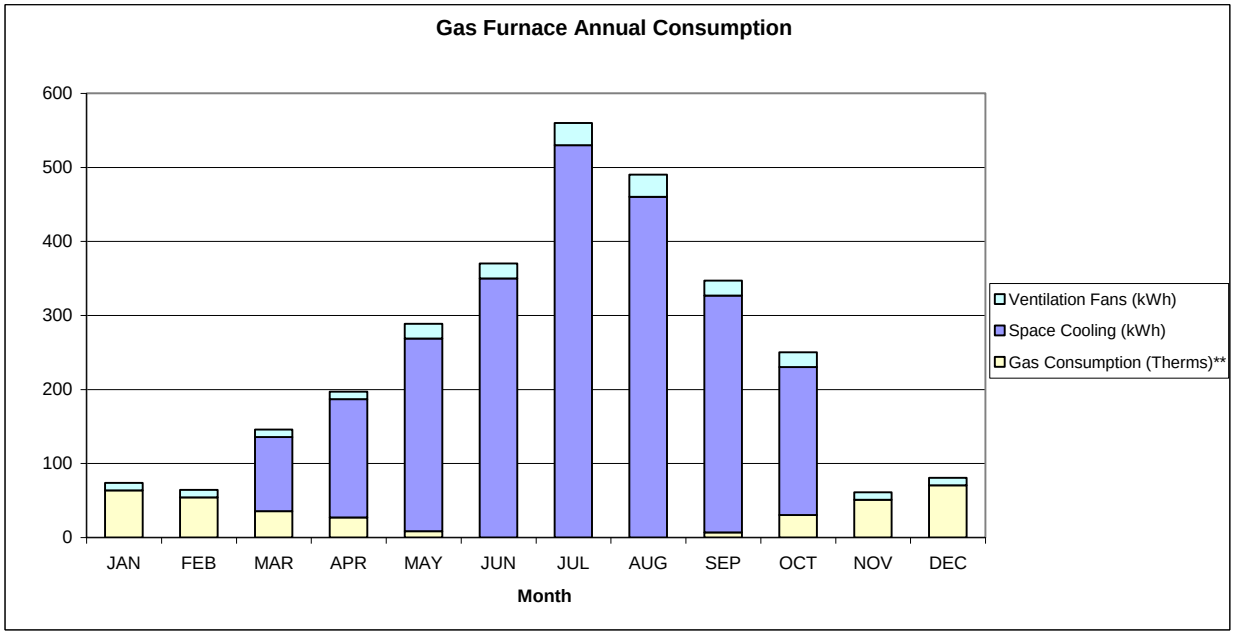
Heat Strip (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	80	120	20	290	440	380	260	160	0	0	1750
Space Heating	1410	1180	760	560	160	0	0	0	120	630	1090	1560	7470
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	30	220
Ventilation Fans	0	0	10	10	10	20	30	30	20	10	0	0	140
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	30	220

GSHP Vertical (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	60	90	150	200	320	290	200	130	0	0	1440
Space Heating	350	300	190	140	40	0	0	0	30	150	270	390	1860
Pumps & Aux.	190	170	130	120	70	60	80	70	70	130	170	190	1450
Ventilation Fans	30	30	20	20	20	30	40	30	30	20	20	30	320
Pumps & Aux.	190	170	130	120	70	60	80	70	70	130	170	190	1450

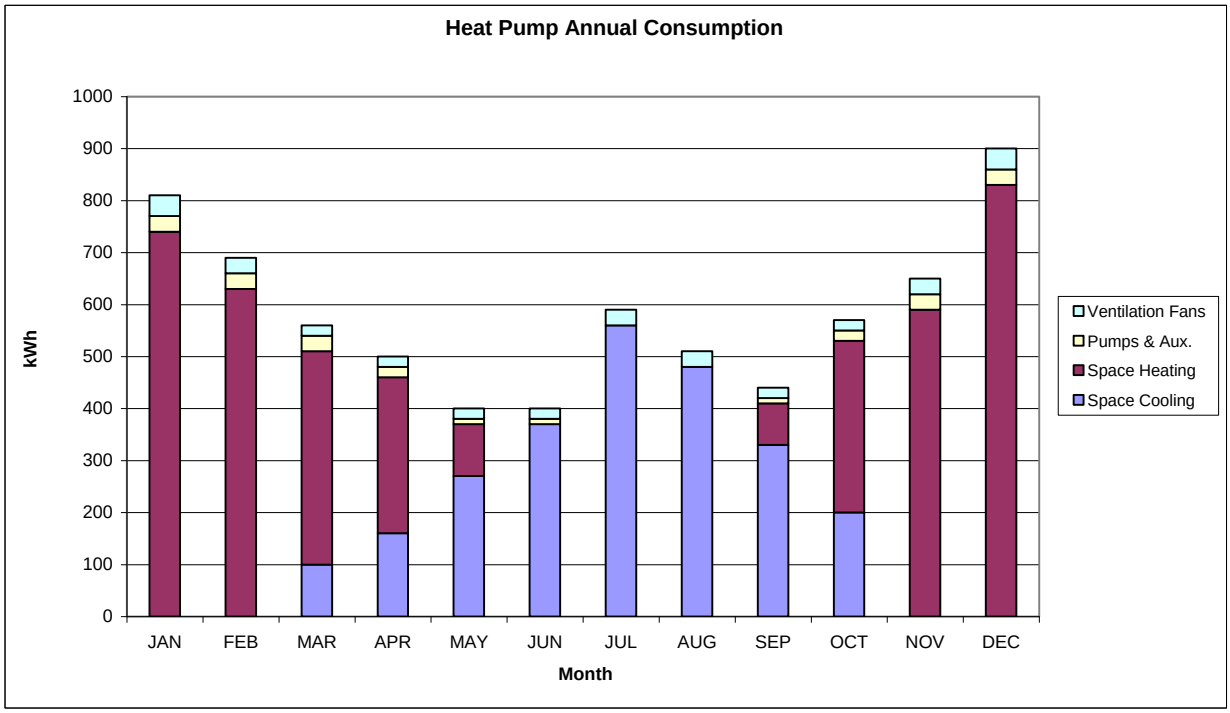
GSHP Horizontal (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	60	100	160	200	310	280	200	120	0	0	1430
Space Heating	380	320	210	150	40	0	0	0	30	160	290	420	2000
Pumps & Aux.	190	170	130	120	70	60	80	70	70	130	170	200	1460
Ventilation Fans	30	30	20	20	20	30	40	30	30	20	20	30	320
Pumps & Aux.	190	170	130	120	70	60	80	70	70	130	170	200	1460

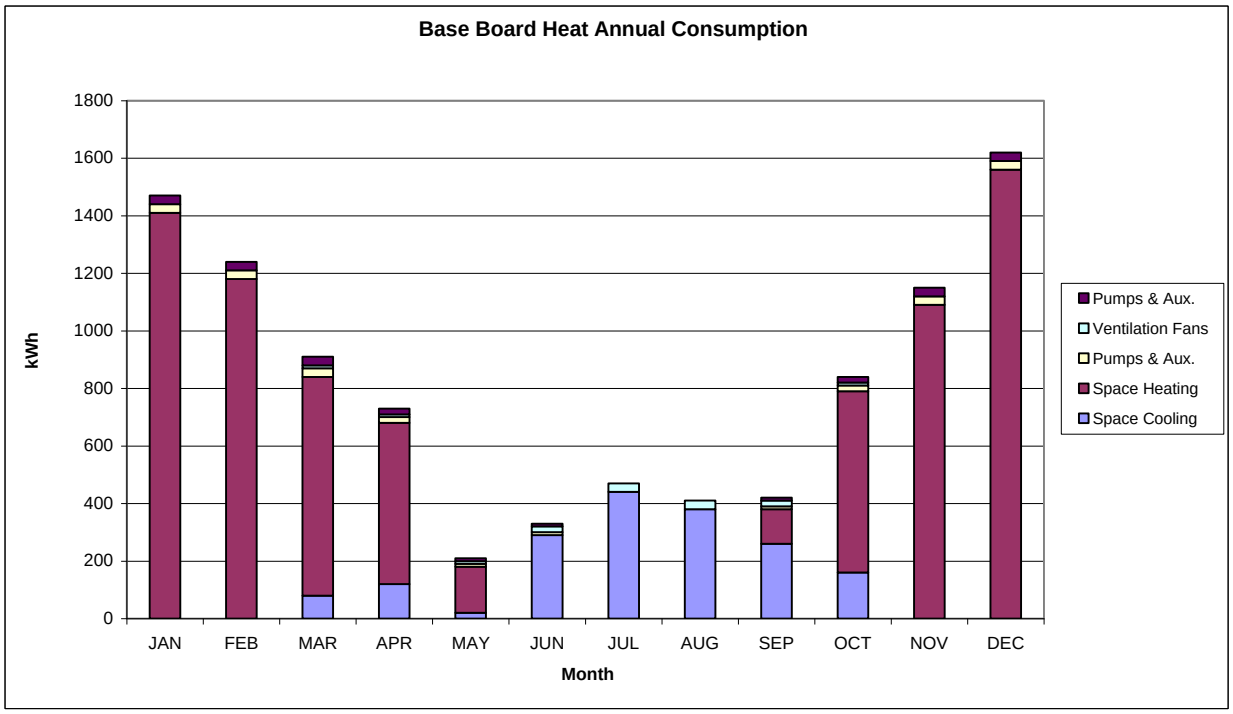
Note: **This value is stated in Propane Gas, as that is the units used by eQuest.

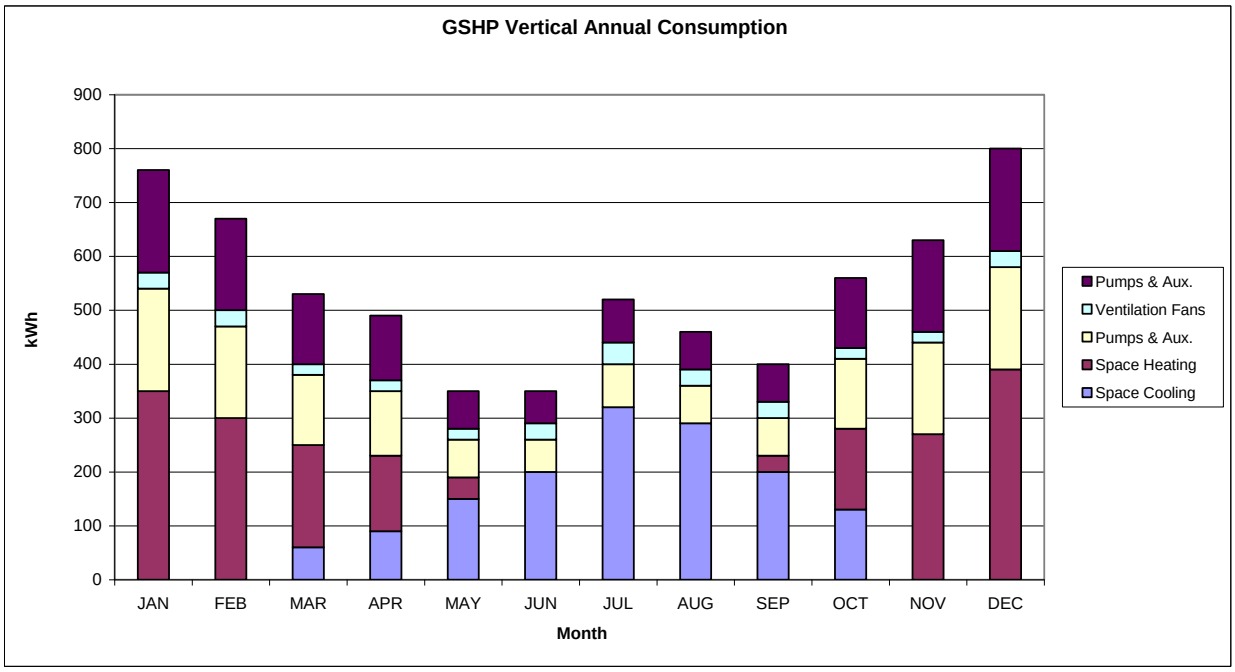
Utility Load Charts

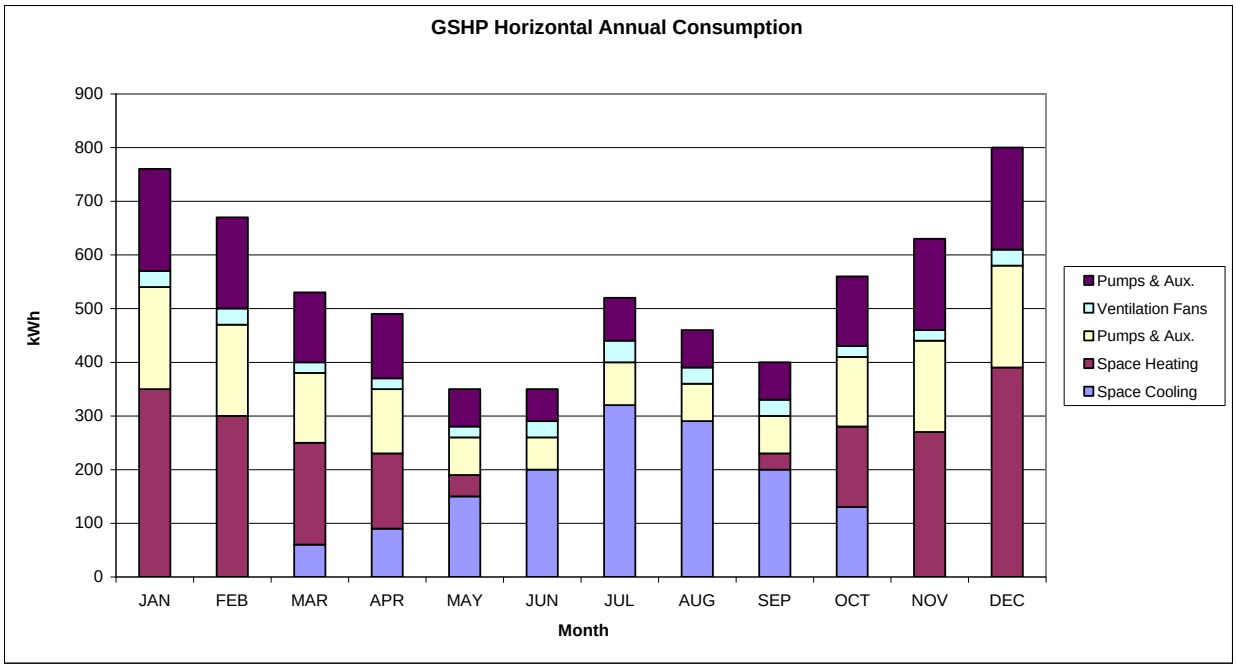


Note: **This value is stated in Propane Gas, as that is the units used by eQuest.




Base Board Heat Annual Consumption
kWh
1800
1600
1400
1200
1000
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Pumps & Aux.
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling


GSHP Vertical Annual Consumption
kWh
900
800
700
600
500
400
300
200
100
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Pumps & Aux.
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling


GSHP Horizontal Annual Consumption
kWh
900
800
700
600
500
400
300
200
100
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Pumps & Aux.
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling

eQuest 3000 SqFt. (5 Ton Model) Data Analysis

Thermal Energy Load

(Note that eQuest considers Heating Load to be Negative and Cooling to be Positive)

eQuest House Load (5-ton, 3000 sq.ft.)				
	COOLING ENERGY (MBTU)	**MAXIMUM COOLING LOAD (KBTU/HR)**	**HEATING ENERGY (MBTU)**	**MAXIMUM HEATING LOAD (KBTU/HR)**
JAN	0.33	15.49	-5.98	-23.75
FEB	0.78	21.64	-4.97	-23.06
MAR	1.53	23.46	-3.02	-18.95
APR	2.60	27.47	-2.09	-16.94
MAY	4.58	27.34	-0.49	-12.96
JUN	6.34	39.03	-0.12	-10.67
JUL	9.39	36.53	-0.02	-4.99
AUG	7.91	37.09	-0.07	-7.61
SEP	5.40	31.98	-0.30	-11.82
OCT	2.90	30.21	-2.41	-17.10
NOV	0.59	18.42	-4.51	-19.93
DEC	0.20	11.66	-6.75	-23.12
TOTAL	**42.54**		**-30.73**	
MAX		**39.03**		**-23.75**

Utility Energy Load

Gas Furnace	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling (kWh)	0	0	90	160	280	400	620	530	340	180	0	0	2600
Ventilation Fans (kWh)	10	10	10	20	20	30	40	30	20	20	10	10	230
Gas Consumption (Therms)**	78	66	41	30	8	0	0	0	5	34	61	87	409

Heat Pump (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	10	170	300	420	630	540	350	190	0	0	2610
Space Heating	870	740	450	310	80	0	0	0	50	340	670	990	4500
Pumps & Aux.	30	20	20	20	10	10	0	0	10	20	30	30	200
Ventilation Fans	10	10	10	20	20	30	40	30	20	20	10	10	230

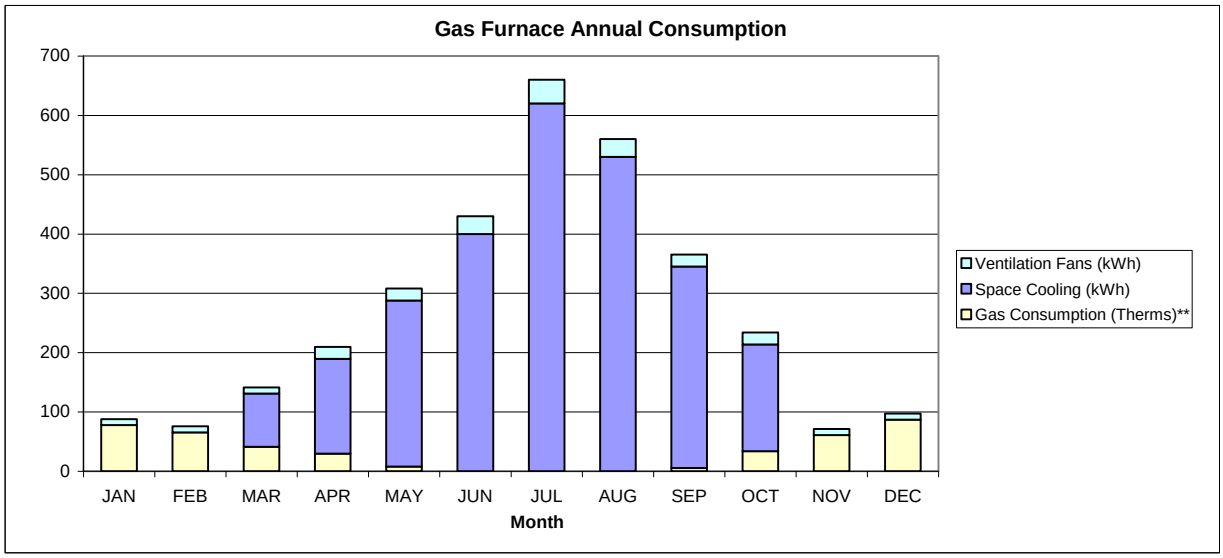
Heat Strip (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	90	160	280	400	630	530	340	180	0	0	2610
Space Heating	1680	1400	850	590	140	0	0	0	90	680	1270	1890	8590
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	40	230
Ventilation Fans	10	10	10	20	20	30	40	30	20	20	10	10	230
Pumps & Aux.	30	30	30	20	10	10	0	0	10	20	30	40	230

GSHP Vertical (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	70	120	220	300	470	420	280	150	0	0	2030
Space Heating	420	350	210	150	30	0	0	0	20	160	310	470	2120
Pumps & Aux.	230	200	150	130	70	60	80	80	70	140	210	250	1670
Ventilation Fans	30	30	20	20	20	20	40	30	20	20	20	30	300
Pumps & Aux.	230	200	150	130	70	60	80	80	70	140	210	250	1670

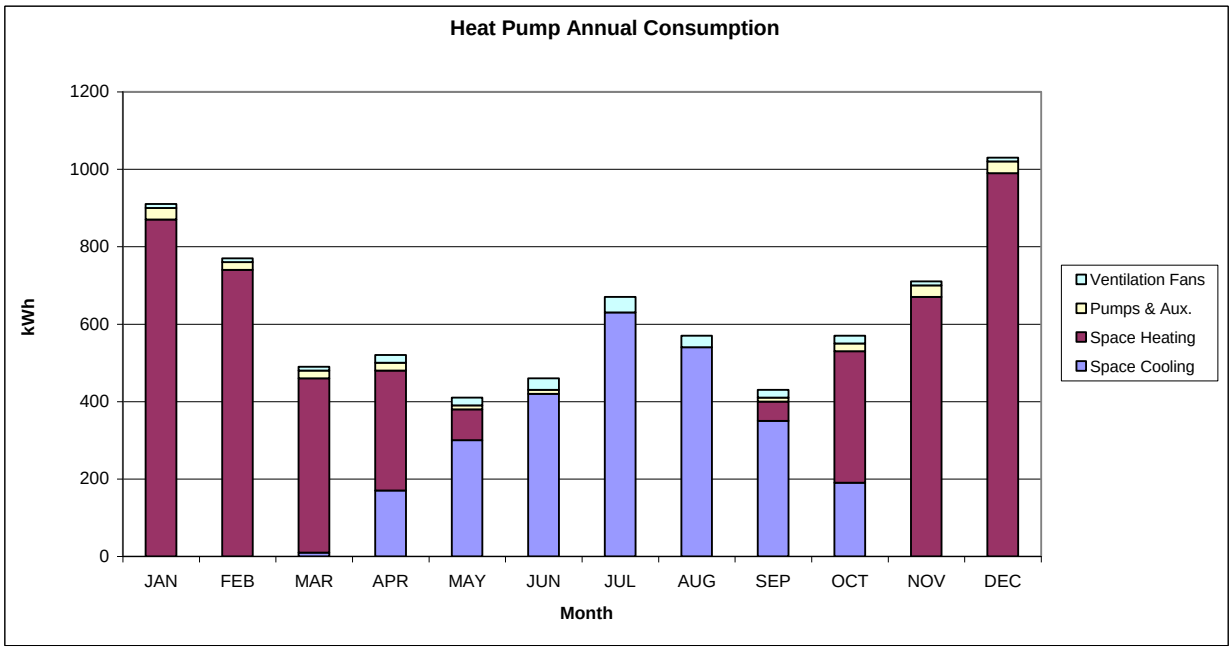
GSHP Horizontal (kWh)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Space Cooling	0	0	70	130	230	320	480	410	270	140	0	0	2050
Space Heating	440	360	220	150	40	0	0	0	20	180	330	490	2230
Pumps & Aux.	230	200	150	130	70	60	80	70	70	150	210	250	1670
Ventilation Fans	30	30	20	20	20	30	40	40	30	30	20	30	340
Pumps & Aux.	230	200	150	130	70	60	80	70	70	150	210	250	1670

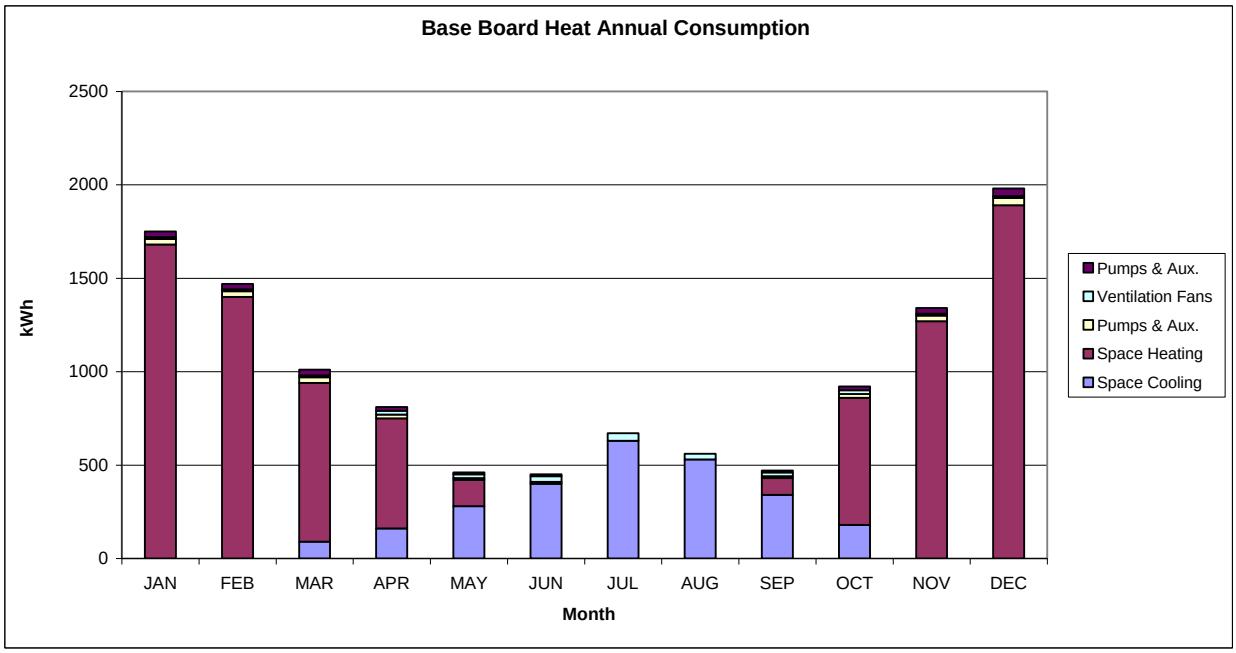
Note: **This value is stated in Propane Gas, as that is the units used by eQuest.

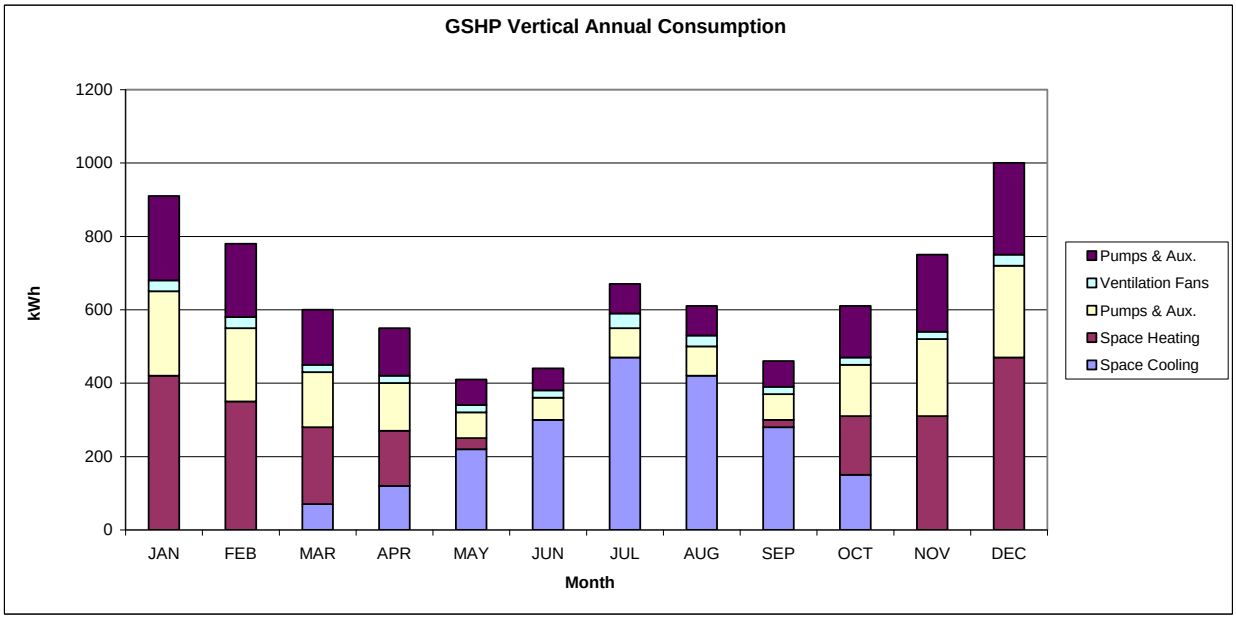
Utility Load Charts

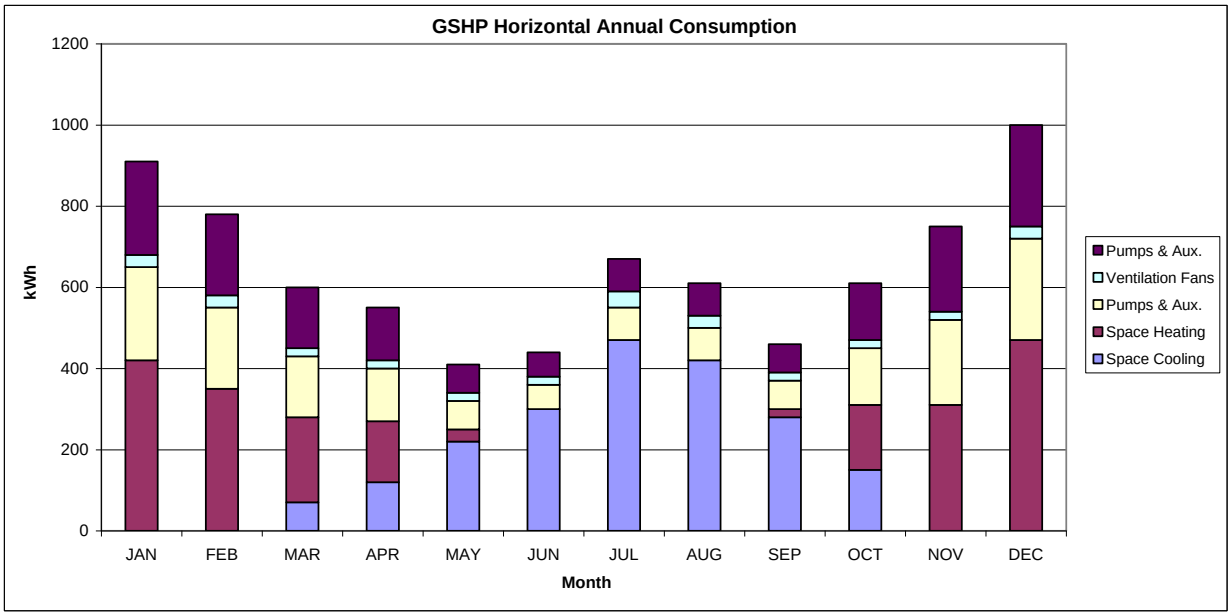


Note: **This value is stated in Propane Gas, as that is the units used by eQuest.




Base Board Heat Annual Consumption
2500
2000
1500
1000
500
0
kWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Pumps & Aux.
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling


GSHP Vertical Annual Consumption
1200
1000
800
600
400
200
0
kWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Pumps & Aux.
Ventilation Fans
Pumps & Aux.
Space Heating
Space Cooling


GSHP Horizontal Annual Consumption
1200
1000
800
600
400
200
0
kWh
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
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GSHP-CALC Results

The results for Vertical Well simulation provided the following guidelines for Well Depth:

- 254 Ft Well Depth, at 3GPM per Ton.
- One well is required per HVAC Ton load.
- Design Lengths *** Heat Pump Series: ClimateMaster (Standard Efficiency) ***
- Required BORE length with minimal groundwater movement = 830 ft (277 ft/bore)
- (Design based on COOLING mode - net annual heat rejection to ground)
- Required BORE lengths with high rates of groundwater movement (or year 1)
- Cooling: L= 760 ft (254 ft/bore), Heating: L= 710 ft (240 ft/bore)
- Unit Inlet (cooling) = 80.0 degrees F
- Unit Outlet (cooling) = 90.2 degrees F
- Unit Inlet (heating) = 40.0 degrees F
- Unit Outlet (heating) = 34.4 degrees F
- Normal ground temp = 55.0 degrees F
- Cooling Load/Demand = 36 MBtuh / 3 kW
- Heating Load/Demand = 36 MBtuh / 3 kW
- Cooling EER (Ht Pump/Sys) = 12.4 / 11.7
- Heating COP (Ht Pump/Sys) = 3.4 / 3.2
- Loop Pump Head/Flow Rate = 60 ft / 9 gpm
- Loop Pump Power/Demand = 0.2 hp / 0.2 kW
- Total Heat Pump Capacity = 44.5 Mbtuh (cooling)
- Total Heat Pump Capacity = 36.7 Mbtuh (heating)
- U-tube Diameter = 1.00 inch
- Separation dist. = 20.0 ft
- Grid = 1 wide by 3 deep
- Grout Conductivity = 0.90 Btu/hr-ft-F
- Bore Diameter = 5.00 inches
- Bore Resistance = 0.219 hr-ft-F/Btu
- Ground Resistance (Cooling) = 0.487 hr-ft-F/Btu
- Ground Resistance (Heating) = 0.487 hr-ft-F/Btu
- Long Term Ground Temperature Rise = 0.3 degrees F
- Thermal Conductivity = 1.27 Btu/hr-ft-degrees F
- Thermal Diffusivity = 0.036 ft^2/day
- Ground Temperature = 55.0 degrees F