Geothermal Heat Pump Economics: *How the Numbers Really Work*

Demystifying the Costs & Benefits of
Geothermal Heating & Cooling Systems

PRESENTER:
Mark Sakry, CGD
Northern GroundSource Inc.
www.NorthernGroundSource.com

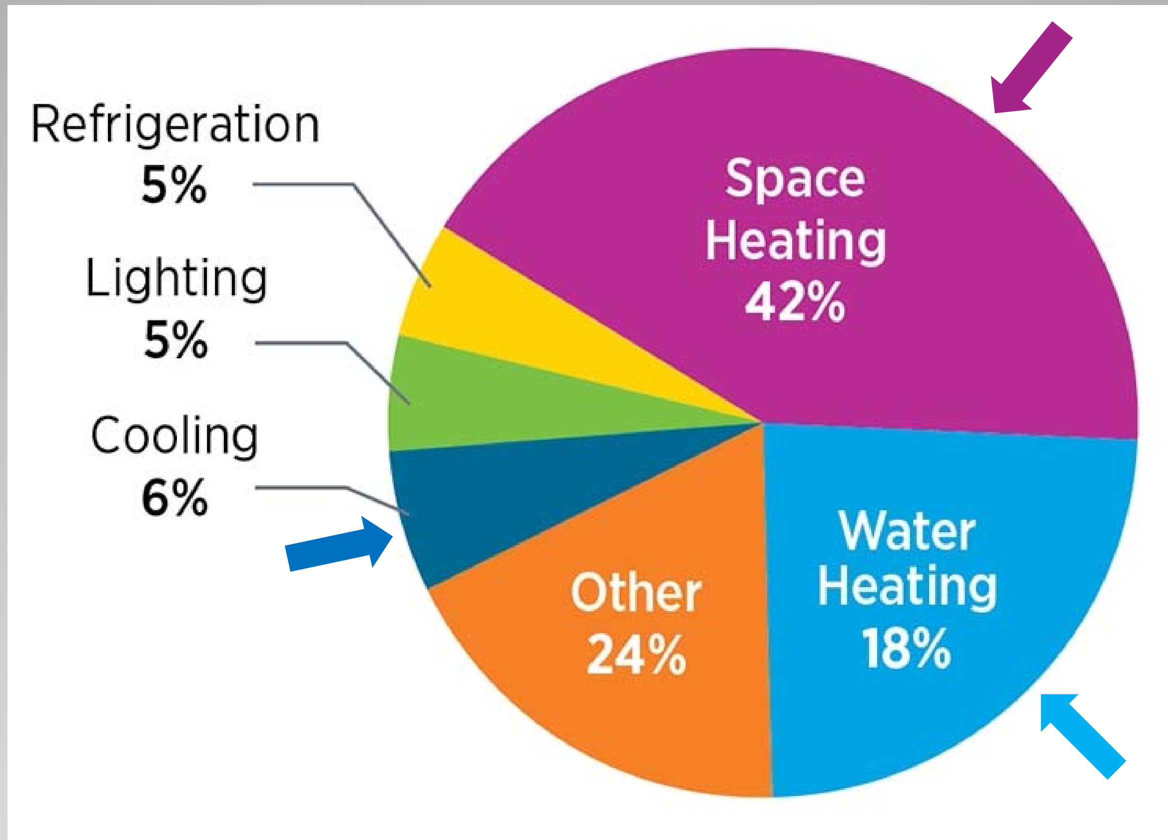
In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code/energy** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

1. The Geothermal Heat Pump Concept

The Simple Logic of a "Ground Source" Approach & Its Ultimate Benefit

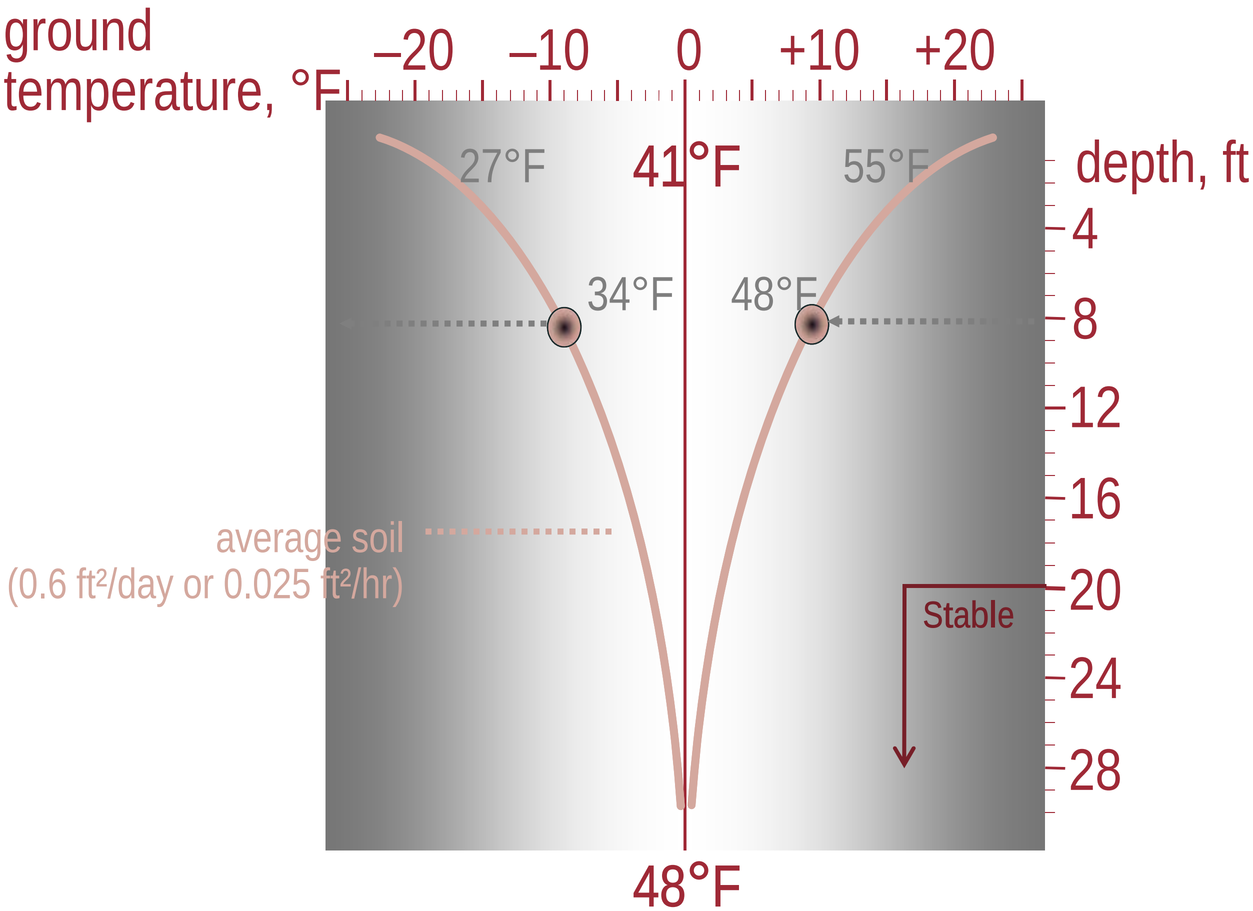


How we use energy in our homes. Heating accounts for the biggest portion of your utility bills. Source: U.S. Energy Information Administration, AEO2014.

Heating Remains #1 U.S. Home Energy Need!

A *common air conditioner* is a simple Air-to-Air Heat Pump—exchanges 74°F indoor air with outdoor temperatures that fluctuate broadly and can often swing to over 100°F.

An *air source heat pump* adds Air-to-Air heating capability—it exchanges 70°F indoor air with outdoor temperatures that can swing well below 20°F (common ASHP operating range limit).



DULUTH SOIL STATISTICS:

MEAN SURFACE TEMPERATURE 1 ft. = 41°F

ANNUAL SWING = 28°F

DAYS TO MINIMUM = 37

DEEP EARTH TEMPERATURE = 48°F

Where might we find temperatures nearby that are <u>moderate</u> and <u>stable</u> all year round?

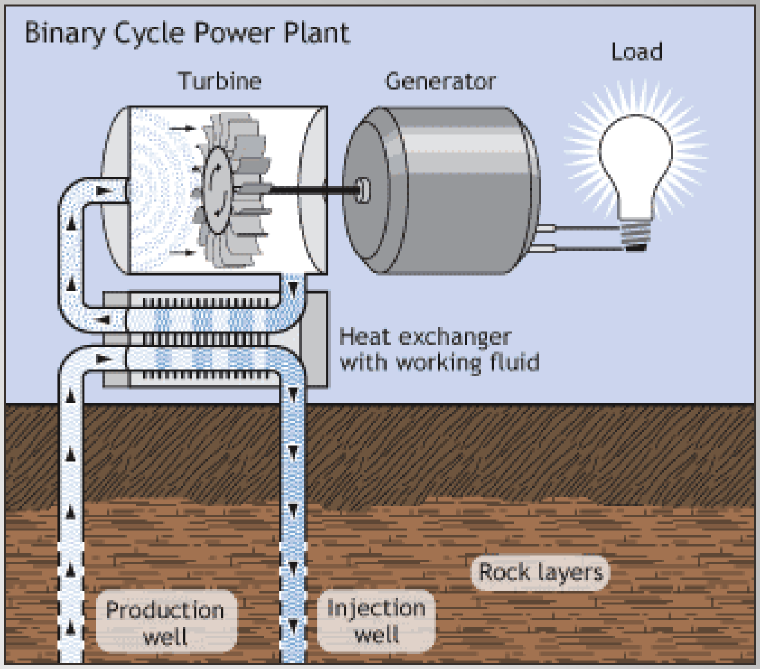
Heat pump technology logically goes…underground! (Video)

Heat pump technology logically goes…underground!

All GHP System Mechanical Equipment is Located Inside.

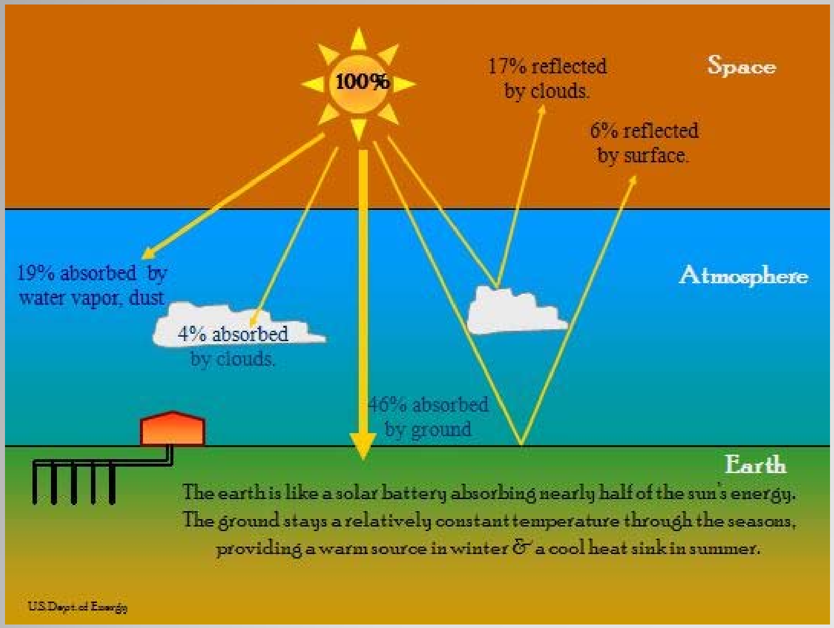
Old Faithful Geyser

“Hot Rocks” Power



High Grade Geothermal Energy

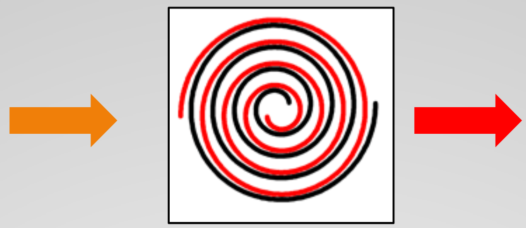
“Solar” Geothermal   GeoExchange Systems



Low Grade Geothermal Energy

Basic Concept: Geothermal Heating

Lower **heat from the ground is "concentrated"**



...into *higher* heat for distribution inside structure

...only a slight energy "penalty" to run the electric motors of a compressor, a couple small pumps and a blower.

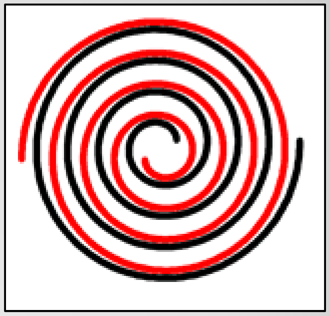
Introducing: The Compressor

SCROLL COMPRESSOR

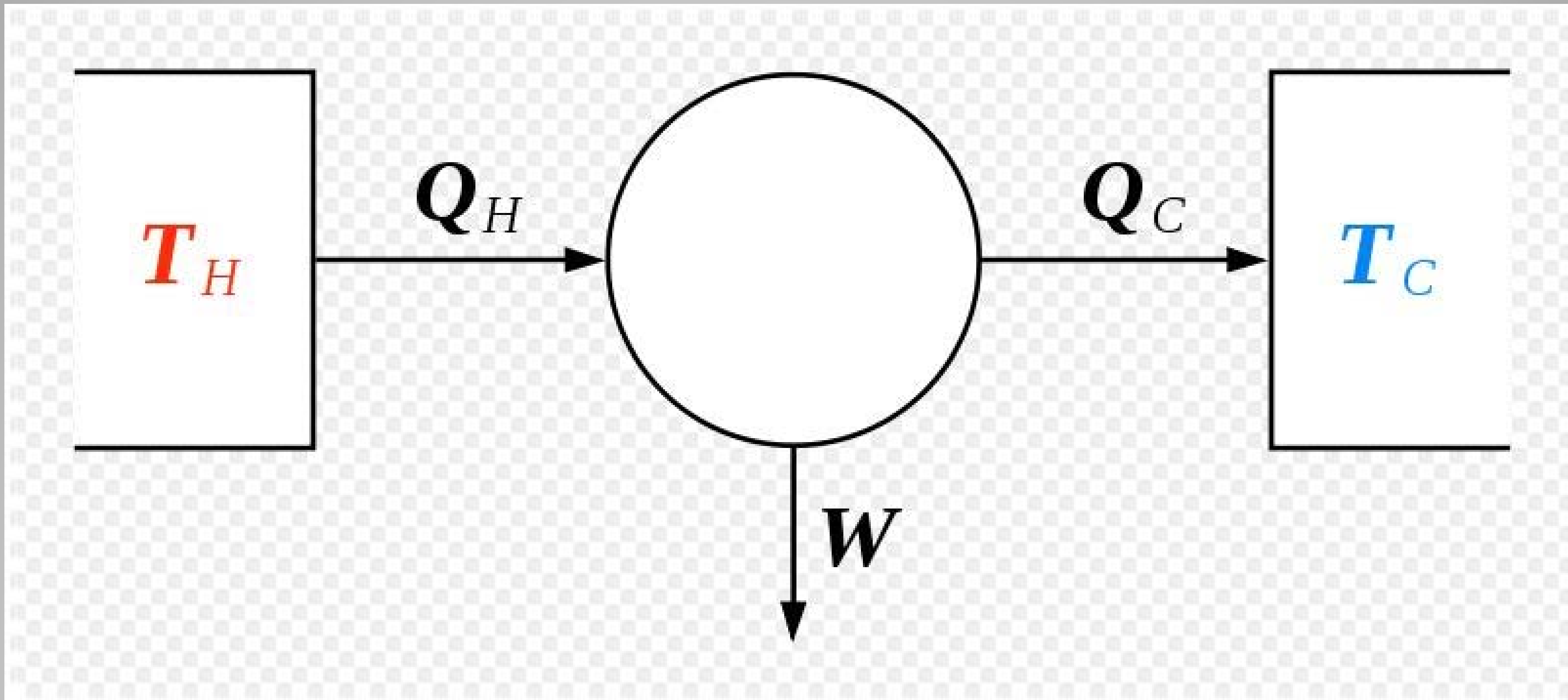
The Compressor is the GHP's **primary working unit** where gas is compressed, heated, and "pumped" to its heat exchange delivery point.

A **refrigerant** gas (with much better heat concentrating properties than air) is used.

SCROLL: TOP VIEW

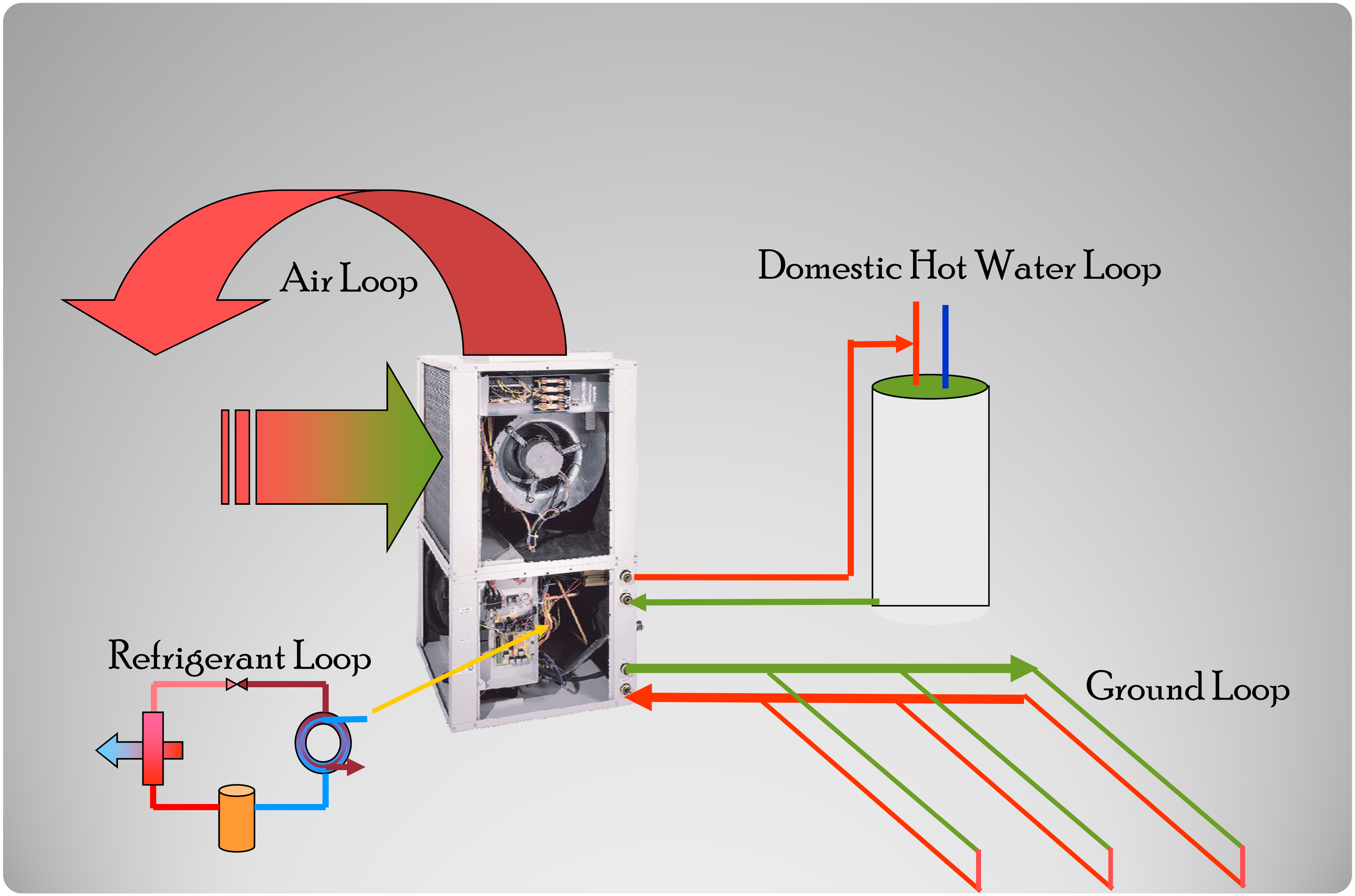


Zeroth Law of Thermodynamics

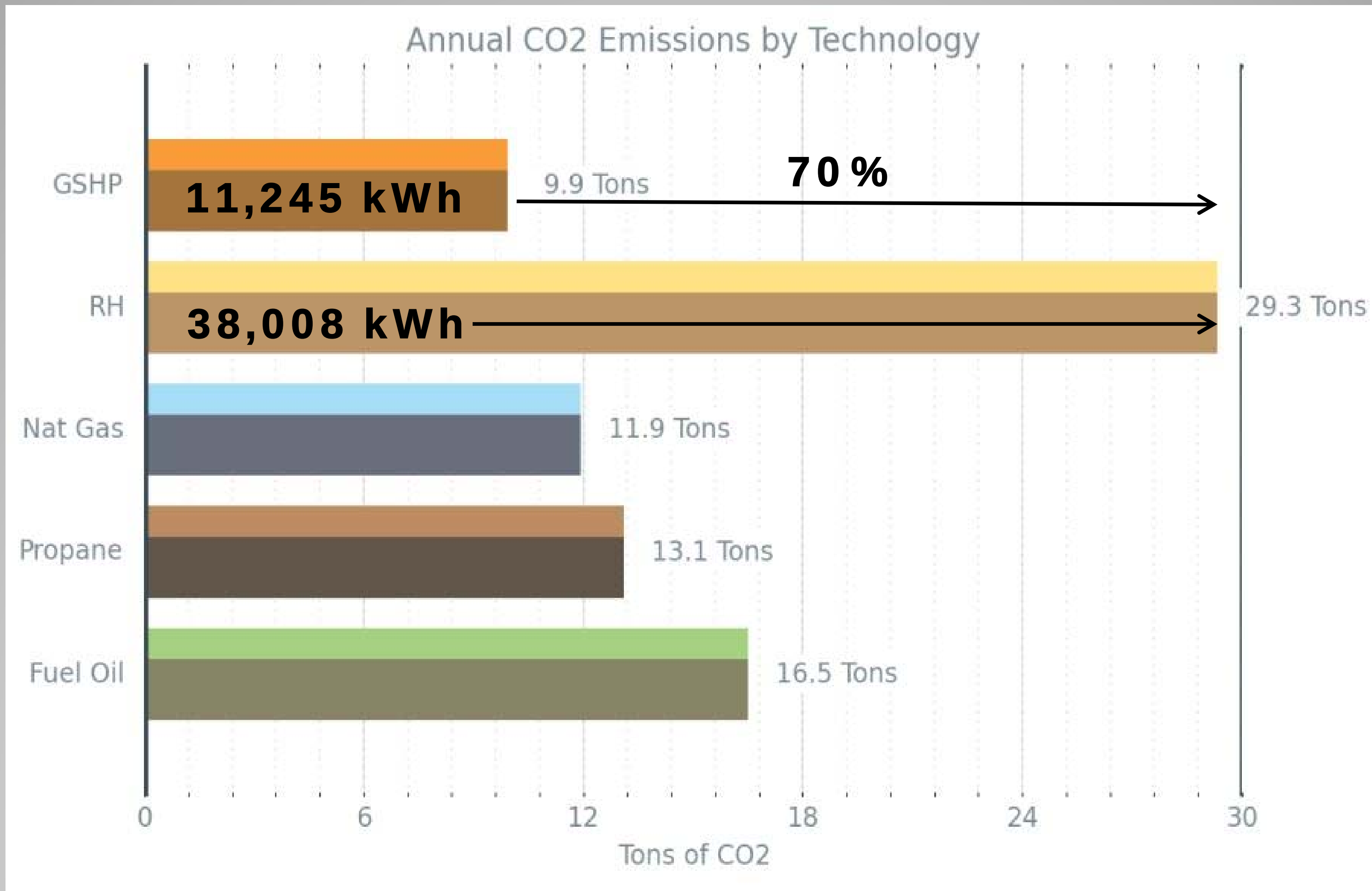


WIKIPEDIA: When two systems...are brought in diathermic contact with each other they exchange heat to establish a thermal equilibrium between each other.

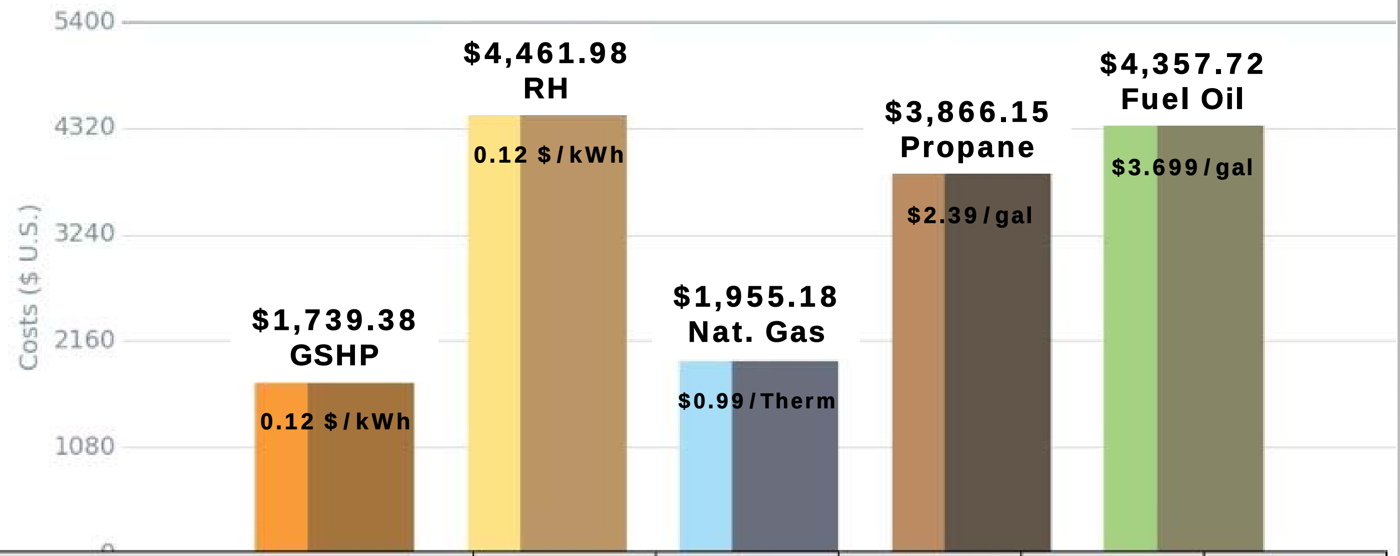
Heat moves to Cold...Always!



Typical Forced Air GHP System



<u>ULTIMATE BENEFIT</u>: OVER 70% OF HEAT ENERGY IS FROM GROUND!



System Type	Heating	Cooling	Hot Water	Total	vs. GSHP
Ground Source Heat Pump (GSHP)	$1,270.51	$86.00	$382.87	$1,739.38	——
RH	$3,817.20	$108.48	$536.30	$4,461.98	$2,722.60
Nat Gas	$1,310.40	$108.48	$536.30	$1,955.18	$215.80
Propane	$3,221.37	$108.48	$536.30	$3,866.15	$2,126.77
Fuel Oil	$3,712.94	$108.48	$536.30	$4,357.72	$2,618.34

ANNUAL ENERGY COSTS FOR TYPICAL 4 TON HOME IN DULUTH

2. What Does a Geothermal System Cost?

Examining the main factors that determine GHP system cost.

How much is a car?

2. What Does a Geothermal System Cost?

Examining the main factors that determine GHP system cost.

GHP System Cost Factors

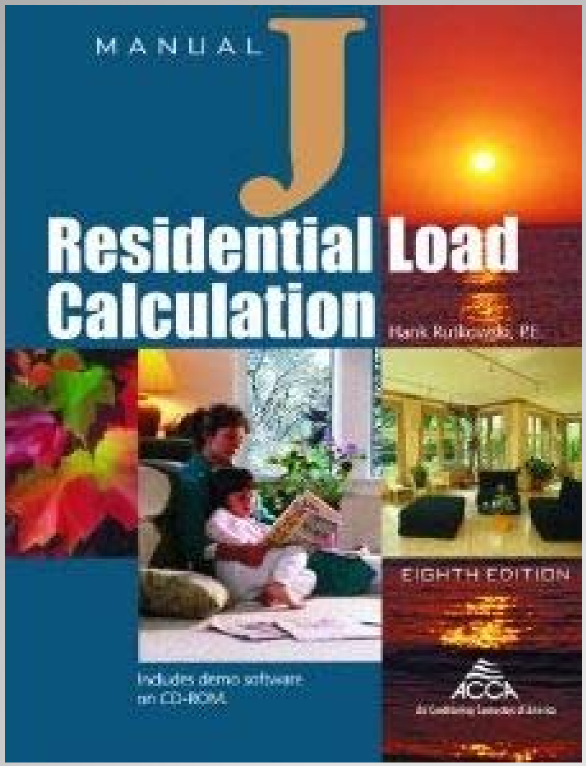
- GHP System Sizing
- Site Geology & Conditions
- Delivery System Preferences
- GHP Configuration
- Electric Power Requirements
- Incentive Programs
- Quality of Equipment
- Quality of Installation

➢ GHP System Sizing

- **The first most critical step in establishing GHP system cost is accurate <u>system sizing</u>**

- **Proper sizing is achieved by first establishing the <u>peak heating load</u> of the structure (peak cooling load is used in South)**

- **As peak load increases, so does GHP system sizing requirement…and therefore <u>cost</u>.**



		Zone Length		Zone Width		Zone Height		Total Cu. or Sq. Feet
Approx. Air Changes / Hr.:	0.2							
Air Infiltration Rate (CFM):	57							
Approx. Zone Volume in Cubic Feet		43.54	x	43.54	x	9.00	=	17,062
Approx. Zone Area in Square Feet		43.54	x	43.54	x		=	1,896
Approx. Exposed Wall Area In Sq. Ft.		174.16	x		x	9.00	=	1,567
Indoor Dry-Bulb Design Temperature:		68		Degrees F.		Less Window Area:		75
Outdoor Dry-Bulb Design Temperature:		-27		Degrees F.		Less Door Area:		22
Design Temperature Difference:		95				Actual Wall Area:		1,470

Structural Element	Structural Element Description	Area (Sq. Ft.)		Element U-Value		Temperature Difference		Total BTUH
Above Grade Ext. Wall Info	2 x 4 (R-13)+		x	0.0718	x	95	=	0
	2 x 6 (R-19)+	349	x	0.0526	x	95	=	1,745
	ICF (R-24)+	1,121	x	0.0417	x	95	=	4,437
Window Information	Single Pane		x	0.5510	x	95	=	0
	Triple Pane (Opp.)		x	0.2400	x	95	=	0
	Triple Pane (Fixed)		x	0.1800	x	95	=	0
	Double Pane	75	x	0.3100	x	95	=	2,209
Exterior Door Information	Solid-Core Wood		x	0.2525	x	95	=	0
	1-3/4" 24 ga. Steel		x	0.1686	x	95	=	0
	1-3/4" 18 ga. Steel		x	0.2257	x	95	=	0
	Deluxe with Storm	22	x	0.3100	x	95	=	648
Roof / Ceiling Information	R-38+		x	0.0257	x	95	=	0
	R-40+		x	0.0244	x	95	=	0
	R-42+		x	0.0233	x	95	=	0
	R-44+		x	0.0223	x	95	=	0
	Other		x	0.0000	x	95	=	0
Above Grade Exposed Floor (Crawl Space)	2 x 8 (R-24)+		x	0.0401	x	95	=	0
	2 x 10 (R-28)+		x	0.0346	x	95	=	0
	2 x 12 (R-33)+		x	0.0295	x	95	=	0
	Other		x		x	95	=	0
Cement Slab	Slab on Grade		x	0.0638	x	95	=	0
Below Grade Structural Elements	Structural Element Description	Area (Sq. Ft.)		BTUH Loss Factor				
	Floor	1,896	x	3.00		BTUH per Sq. Ft.	=	5,688
	Walls		x	6.00		BTUH per Sq. Ft.	=	0
Air Losses	Air Loss Description	Air CFM		Loss Factor		Temperature Difference		
	Infiltration	57	x	1.1	x	95	=	5,955
	Ventilation & Make-Up	25	x	1.1	x	95	=	2,613
Duct Loss	Is Ductwork in an Unconditioned Space?	Yes / No		HL Factor		Subtotal	=	23,295
		No		0.00	x	23,295	=	0

(+ Indicates inside and outside air film is calculated in u-value)
(U-value = 1 / R-value = BTUH / Sq. Ft. / degree F. Td)
(Air loss factor = BTUH / CFM / degree F. Td)

Total Heat Loss: 23,295
853 - 1137 CFM
→ 64,989 BTUH

Accepted Load Calculation Standard:

Use "Manual J" Referenced Software

IN GENERAL: *As heat requirement increases—GHP system sizing increases proportionately…along with the total system design and installation cost!*

Heating Estimate Design Data	w/o Desuper	w/Desuper
Estimated BTU/Hr Heat Loss:	50,000	50,000
Heat Pump BTU/Hr Output:	45,500	41,405
Number of Kw of Aux Ht Suggested:	2	3
Heat Pump C.O.P.:	3.60	3.60
Overall H.P. Heating System C.O.P.:	3.57	3.54
Heating Degree Days:	9,789	9,789
Temperature Difference:	100	100
Correction Factor:	0.80	0.80
KWH Rate for Heat Pump:	$0.115	$0.115
KWH Rate For Aux. Electric Heat:	$0.115	$0.115
KWH Rate for Furnace Fan:	$0.115	$0.115

Conventional Source Table		Units	Efficiency	Cost
Other Fuel Source	1 Electric (Radiant)	KWH	100%	$0.130
	2 Electric (Forced Air)	KWH	100%	$0.130
	3 Fuel Oil	Gallon	80%	$3.750
	4 L.P. Gas	Gallon	90%	$1.899
	5 Natural Gas	Therm	90%	$0.999

Conventional Source Selection	Heating	DHW
Number of Other Energy Source:	3	1
Other Source Efficiency:	80%	100%
Other Source Cost or Rate:	$3.750	$0.130

Alternate Load Method (Retrofits):
Based on Fuel / Electric Usage History

Estimated Energy Consumption		Heating		Cooling	DHW	Estimated Annual Totals	
		w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump	Kwh/yr	7,583	7,520	377	650	7,959	8,547
Auxiliary Ht and Electric Water Htr	Kwh/yr	237	464		1,965	237	2,429
Other Fuel Source: 1. Electric (Radiant)	Kwh/yr				4,549	4,549	
2. Electric (Forced Air)	Kwh/yr			691		691	
3. Fuel Oil	Gallons/yr	851				851	
4. LP Gas	Gallons/yr						
5. Natural Gas	Therms/yr						

Estimated Operating Costs	Heating		Cooling	DHW	Estimated Annual Totals	
	w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump	$871.99	$864.76	$47.11	$74.77	$919.09	$986.63
Auxiliary Ht and Electric Water Htr	$27.28	$53.30		$226.00	$27.28	$279.31
Other Fuel Source: 1. Electric (Radiant)				$591.32	$591.32	
2. Electric (Forced Air) *			$86.36		$86.36	
3. Fuel Oil *	$3,322.23				$3,322.23	
4. LP Gas *						
5. Natural Gas *						

Estimated Cost Savings	Heating		Cooling	DHW		Estimated Annual Totals	
	w/o	w/Desuper		w/o	w/Desuper	w/o Desuper	w/Desuper
Conventional Heating, Cooling and DHW	$3,322.23	$3,322.23	$86.36	$591.32	$591.32	$3,999.91	$3,999.91
ECONAR GeoSource Heat Pump	$899.27	$918.06	$47.11	$591.32	$300.77	$1,537.70	$1,265.94
Savings Using ECONAR Heat Pump	**$2,422.96**	**$2,404.16**	**$39.25**	**$0.00**	**$290.56**	**$2,462.21**	**$2,733.98**

Alternate Load Method (Retrofits): Based on Fuel/Electric Usage History

Duluth Home
5,300 sq' = 70,000 BTUH

Finland Community Center
10,000 sq' = 160,0,000 BTUH

Consider that GHP installation costs and benefits are *scalable!*

Foxboro, WI = 60,000 BTUH   Babbitt, MN = 70,000 BTUH

A 6T home built in Foxboro, WI might be a 7T home in Babbitt, MN

1 Ton (British) = 12,000 BTUH

BUT…

A cold climate GHP system might have a design output of only 10,000 BTUH / Ton

A "Ton" is a long-established British thermal unit we still use

EXAMPLE 1:

5 Ton GHP (SM060)

60,300 BTUH Output @ 50°F EWT
48,000 BTUH Output @ 32°F EWT

The colder the fluid temperature from the loop…the lower the output of the GHP

GHP output depends on the fluid temperature entering from the loop

EXAMPLE 2:

Horizontally-trenched loop circuits for cold climate GHP systems:

1 Loop ≈ 8,000 to 10,000 $BTUH_{PEAK\ TON}$

Approx. 1 loop circuit of sufficient length for every 10,000 BTUH of the peak heating load

Loop Sizing Follows Peak Heating Load…Not Just GHP Capacity!

Peak heating Load = 49,537 BTUH
(Future Insulation = 41,761 BTUH)

4.0<5T GHP (TVC048) @ 30°F EWT = 45,500 BTUH

➢ Site Geology & Conditions

- One of the most limiting factors in determining GHP system cost is site geology and conditions
- A primary objective is to achieve maximum GHX performance benefit at minimal cost and impact to site
- Different kinds of loops come at different cost… and mostly achieve the same result

Common GHX Options by Increasing Cost:

- Open Loop / Pump & Dump
- Existing Pond & Lake Loops
- Horizontally Trenched or Excavated
- Excavated Pond Loop
- Horizontally Drilled
- Vertically Bored in Deep Soil/Overburden
- Vertically Bored in Rock

Common GHX/Loop Options

Instead of a buried closed loop GHX, domestic water from house is simply pumped through the GHP coil then discharged somewhere outside. *(Pictured is a simple shallow drain tile in sand.)*

Open Loop / Pump & Dump Systems

Main Cost Factors:

- Well must have sufficient recovery rate
- Size of well pump might slightly increase
- Cycle-stop or variable speed pump often specified (driller advises)
- Flow control assembly required at GHP
- Discharge pipe trench & site drainage
- State water use limits may eliminate option (MN: 10K gal/day—1M gal/year)

Open Loop / Pump & Dump Systems

Existing Pond & Lake Loops

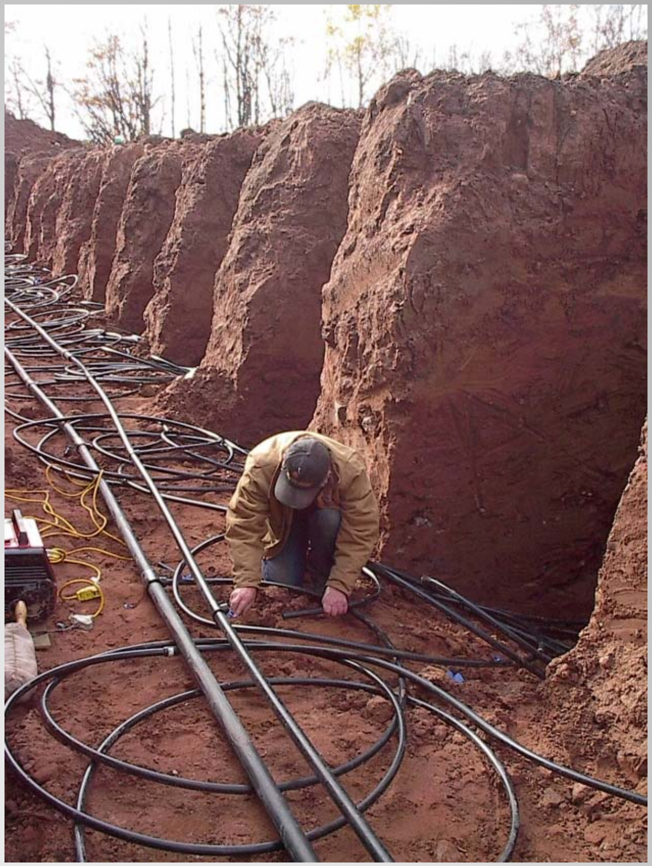
Existing Pond & Lake Loops

Main Cost Factors:

- Lake permits difficult to obtain, usually ruled out as option if other options exist
- Pond expansion sometimes required
- Less loop pipe but more labor and other materials for weighting and containment
- Ground loop excavation eliminated, but still requires a S/R pipe trench

Closer Spacing = longer pipe requirement, smaller consolidated excavation footprint (500 ft^2/T)

Wider Spacing = shorter pipe requirement, expanded excavation footprint (1,000 ft^2/T)



Horizontally Excavated

Main Cost Factors:

- Excavation cost…per site conditions!
- Unknown or unforeseen encumbrances
- Loop size and configuration (at roughly 1 loop circuit per 10K BTUH of peak load)
- Largest footprint, greater impact to site
- Finished landscaping and vegetation (excavation is commonly rough-in only)

Horizontally Excavated

Pond Heat Exchangers combine exceptional GSHP system performance…

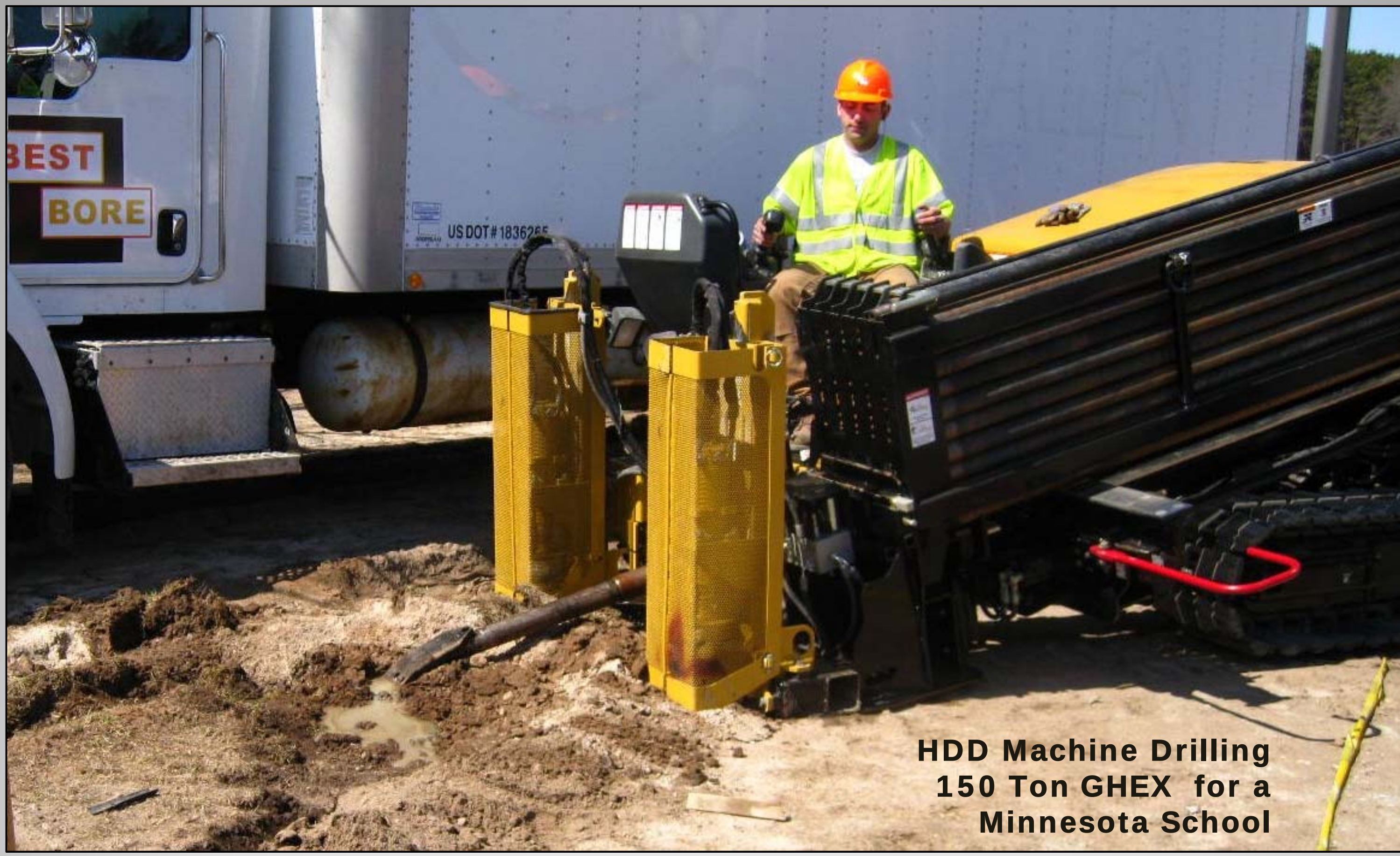
With an aesthetic component you just can't get from a conventional earth loop.

Excavated Pond

Main Cost Factors:

- Possible wetland concerns
- Loop footprint roughly same as an excavated GHX
- Must deal with displaced soil material
- Additional containment materials or 1′-2′ sand/gravel backfill required

Excavated Pond



HDD Machine Drilling 150 Ton GHEX for a Minnesota School

Horizontally Drilled

Main Cost Factors:

- HDD loops minimize site impact but usually cost more per design Ton than excavated loops (machine time & grout)
- Unknown or unforeseen encumbrances
- Loop size and configuration by qualified designer using design software
- Some excavation still required if manifold is buried (interior manifold also adds cost)

Horizontally Drilled

Vertically Bored in Deep Soil

Main Cost Factors:

- Vertically bored ground loops may require less pipe than HDD but usually cost more for machine, crew and grout
- Depth of unconsolidated overburden
- Loop size and configuration by qualified designer using design software
- Excavation required to connect loops, impact determined by bore field footprint

Vertically Bored in Deep Soil

Vertically Bored in Rock

Main Cost Factors:

- Drilling through dense rock requires heavier equipment than “mud” drilling, typically at higher cost (including grout)
- Depth of overburden for extracting casing
- Loop size and configuration by qualified designer using design software
- If header excavation is over shallow rock, a costly insulation detail may be required

Vertically Bored in Rock

➢ Delivery System Preferences

- Geothermal heating is inherently a <u>low-temperature</u> technology
- Heat delivery systems must conform to GHP temperatures <u>not</u> the other way around
- Combining hydronic radiant heating with forced air heating and/or cooling generally <u>adds cost</u> to the GHP system itself
- GHP system configuration follows delivery system preferences if they are <u>compatible</u>

Supply Side (GSHP)

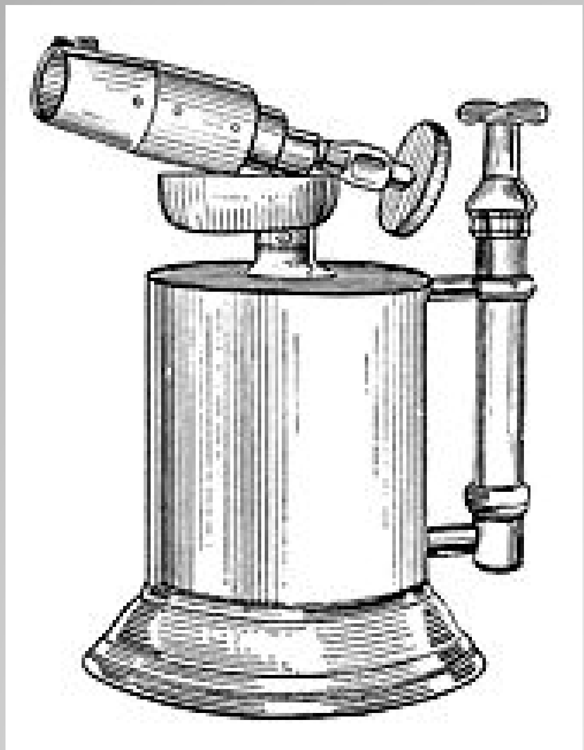
- Ground Heat Exchanger (GHX)
- Ground Source Heat Pump (GSHP or GHP)
- Loop Pump or Flow Center
- Some Peripheral and Auxiliary Components (incl. Controls)

Delivery Side (HVAC)

- Duct System (incl. Air Exchanger)
- Radiant Floor Tubing, Manifolds, Zone Pumps and Controls
- Radiant Baseboards, Panels, Radiators
- Plumbing/Piping Delivery Systems

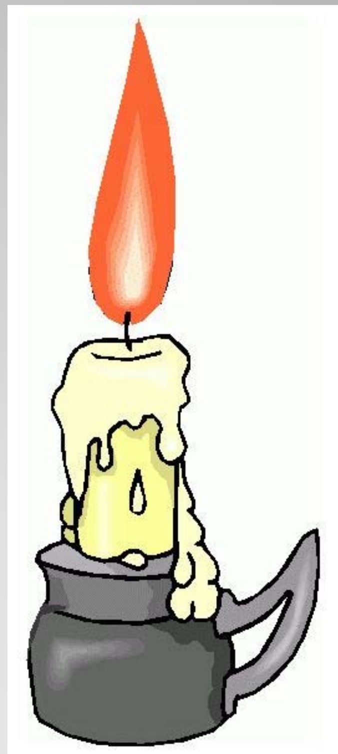
The "geothermal system" is generally assigned to the "supply" side of heating/cooling functions.

High Temp @ 50,000 BTUH!



130°F - 180°F

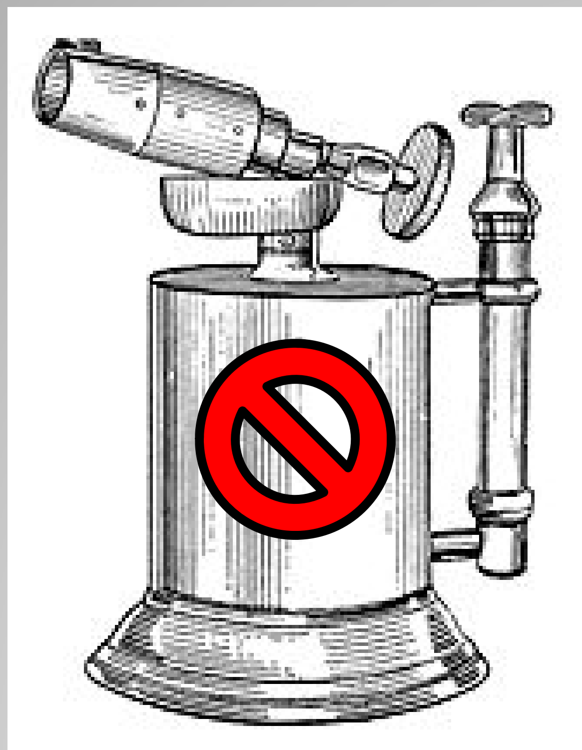
Low Temp @ 50,000 BTUH!



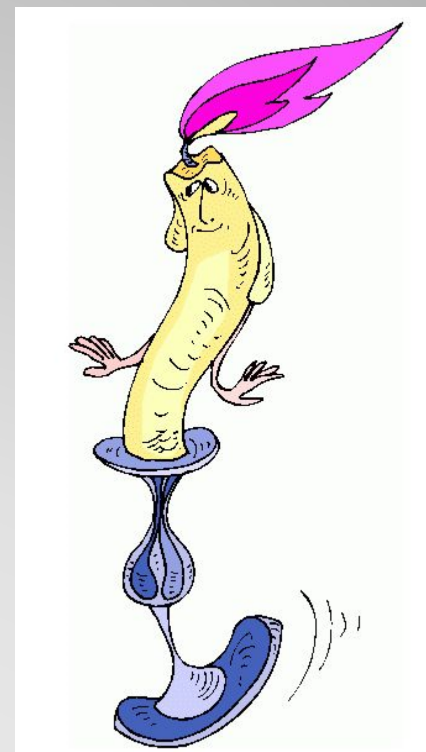
85°F - 115°F

High Temp *versus* Low Temp?

~~High Temp @~~
50,000 BTUH!

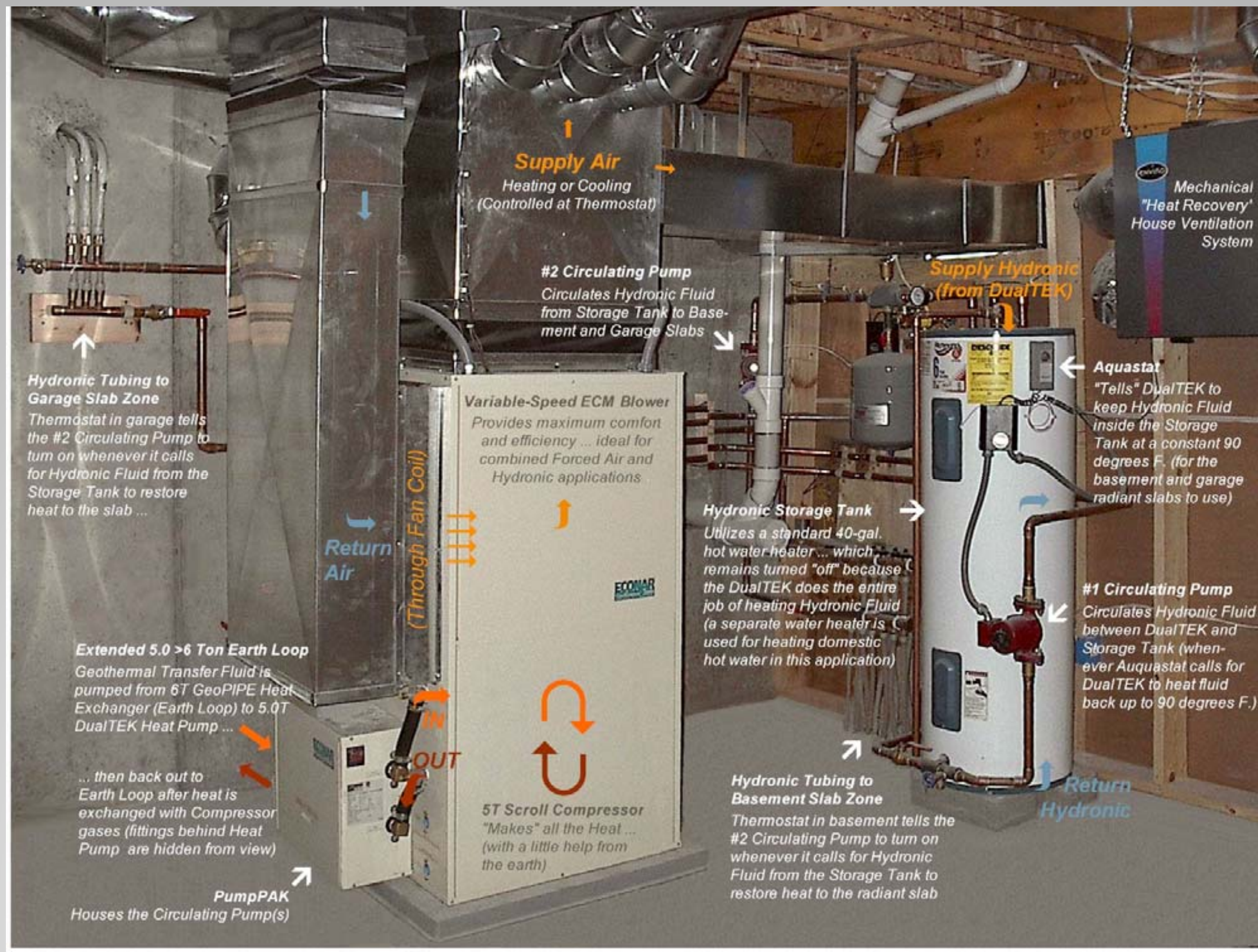


Low Temp @
50,000 BTUH!



GENERAL PREMISE: The Lower the Temperature—the Higher the Efficiency!

➢ GHP Configuration



➢ GHP Configuration

GHP SYSTEM COST OPTIONS—33,645 BTUH HOME:
(Not including any HVAC 'delivery' side costs)

3.0<4T Forced Air Heating & Cooling
Requires full house duct system only.

$18K GHP/GHX + Approx. $3.5K Excavation = **$21.5K**

3.0<4T Hydronic Heating Only
Requires radiant floor tubing only but some minimal ductwork for ventilation system.

$20K GHP/GHX + Approx. $3.5K Excavation = **$23.5K**

3.0<4T Hydronic Heating & Cooling (Split System)
Requires radiant floor tubing plus medium sized duct system.

$25K GHP/GHX + Approx. $3.5K Excavation = **$28.5K**

GHP Configuration

GHP SYSTEM COST OPTIONS W/ GARAGE ADDED
(Not including any HVAC 'delivery' side costs)

5.0T Hydronic Heating Only
Requires radiant floor tubing only but some minimal ductwork for ventilation system.

$22K GHP/GHX + Approx. $4K Excavation = **$28K**

5.0T Hydronic Heating & Cooling (Split System)
Requires radiant floor tubing plus medium sized duct system for house.

$27K GHP/GHX + Approx. $4K Excavation = **$31K**

➢ GHP Configuration

GHP SYSTEM COST OPTIONS W/ GARAGE ADDED
(Not including any HVAC 'delivery' side costs)

5.0T Hydronic Heating Only
Requires radiant floor tubing only but some minimal ductwork for ventilation system.

$22K GHP/GHX + Approx. $4K Excavation = **$28K**

5.0T Hydronic Heating & Cooling (Split System)
Requires radiant floor tubing plus medium sized duct system for house.

$27K GHP/GHX + Approx. $4K Excavation = **$31K**

COST SCALES: $21.5K > $23.5K > $28K > $28.5K > $31K

State-of-the-Art 2-Stage Forced Air GHP System Installation

Older Generation Stand-Alone Combined F/A & HYD GHP System

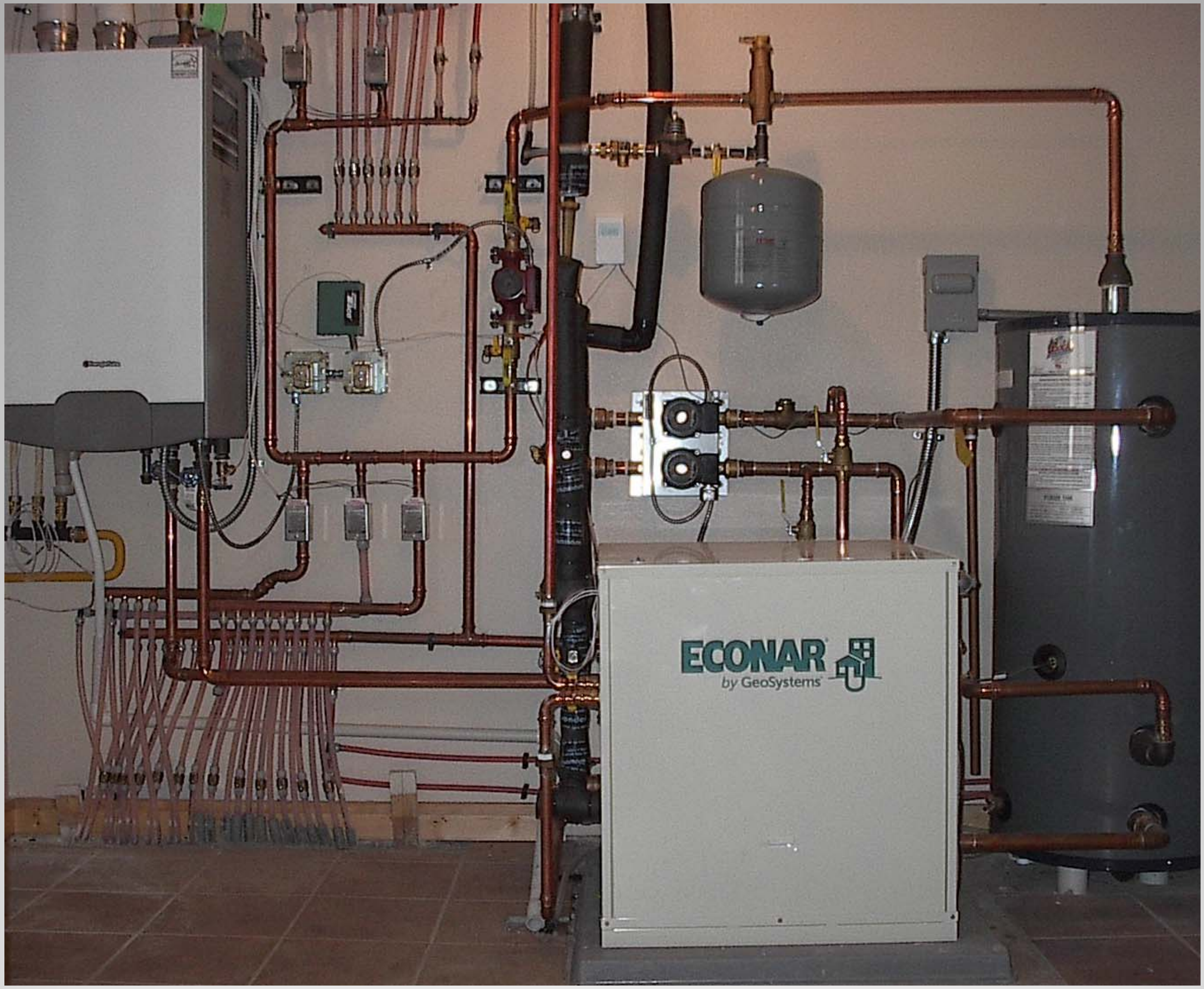
Stand-Alone Forced Air GHPs

Main Cost Factors:

- The higher the GHP Ton, the higher the fan velocity @ 400 CFM/Ton heating load!
- Ductwork sizing and expense increases proportionately by Forced Air GHP Ton

3 Ton GHP @ 400 CFM/Ton = 1,200 CFM
4 Ton GHP @ 400 CFM/Ton = 1,600 CFM
5 Ton GHP @ 400 CFM/Ton = 1,200 CFM
6 Ton GHP @ 400 CFM/Ton = 2,000 CFM

Stand-Alone Forced Air GHPs



HYD Heat Only GHP System

Main Cost Factors:

- No ductwork, low-temp radiant heat only
- Cannot use baseboard, radiators, or staple-up tubing—must use slab, gypsum or some other top-of-floor assembly
- Added hydronic thermal storage (buffer) tank, GHP primary pump(s) and controls
- If Interruptible Dual Fuel (IDF) system, integrated sidearm gas boiler preferred

HYD Heat Only GHP System

Split GHP System (DX)

Main Cost Factors:

- GHP includes DX A-coil for installing inside plenum of gas furnace or other air handler, which are bought separately
- Ductwork can often remain sized to furnace blower, typically only 1,200 CFM
- Eliminates need for outdoor AC/ASHP unit
- Works well for Dual Fuel, but GHP shuts off with <u>any</u> 2nd stage call for gas heat

Split GHP System (DX)

HYD Split GHP System

HYD Split GHP System

HYD Split GHP System

Main Cost Factors:

- Among the most advanced and versatile GHP configurations, but also more costly
- Hydronic air handler/fan coil and controls
- Stainless steel/foam pump packs and pipe insulation for chilled water cooling
- Works exceptionally well for Dual Fuel and 2nd stage with integrated sidearm boiler

HYD Split GHP System

➢ GHP Power Requirements

- The GHP compressor is basically a “small motor” and uses the <u>most</u> energy on the system—demand increases with GHP <u>size</u>
- Fluid pumps and blowers are <u>secondary</u> consumers on the GHP system
- Electrical infrastructure must meet the <u>entire</u> demand of the system <u>including</u> <u>LRA</u>!
- You can run a residential GHP on a small generator, but you can’t <u>start</u> it

➢ GHP Power Requirements

Model	Voltage Code	60 Hz Power		Compressor		ECM Fan Motor FLA	HWG Pump FLA	Ext Pump FLA*	Total Unit FLA	Min Circuit AMPS	Max Fuse HACR	Min AWG	Max Ft
		Volts	Phase	LRA	RLA								
3 TON	1	208/230	1	104	21.2	6.8	0.3	4.0	32.0	37.3	50	8	80
	0	208/230	1	104	21.2	6.8	N/A	N/A	28.0	33.3	80	8	91
4 TON	1	208/230	1	152.9	27.1	6.8	0.3	5.5	39.7	46.5	70	6	102
	0	208/230	1	152.9	27.1	6.8	N/A	N/A	34.2	41.0	60	6	119
5 TON	1	208/230	1	179.2	29.7	9.1	0.3	5.5	44.6	52.0	80	6	91
	0	208/230	1	179.2	29.7	9.1	N/A	N/A	39.1	46.5	70	6	104

- **Electric data for a specific GHP model or series is provided in the engineering manual of most manufacturers**
- **Data typically includes amperage for compressor, blower, external pump(s) and the desuperheater pump**

➢ GHP Incentive Programs

- **Utility Rebate Programs**
- **30% Federal Tax Credit (through 2016)**
- **GHP Installation Financing Programs**
- ***Also consider that geothermal heating and cooling may <u>still</u> offer a good Return on Investment (ROI) even <u>without</u> these!***

2016 Geothermal Rebate Programs

- Minnesota Power

  $200/T Closed Loop ($100/T Open Loop) + $200 ECM

  [Bonuses Frequently Offered: $50/T GSHP + $50 ECM or $100/T & ECM for Triple-E Home]

  http://www.mnpower.com/EnergyConservation/GSHPIncentivePackage

- Great River Energy Affiliates:

  $400/T Closed or Open Loop ($200/T from East Central Energy) + $100 ECM

  Cooperative Light & Power
  http://www.clpower.com/pdfs/2013GSHP.pdf

  Lake Country Power
  http://www.lakecountrypower.coop/viewpage.php?pagename=ratesandrebates

  East Central Energy
  http://www.eastcentralenergy.com/PDFs/gshprebate2014.pdf

  Arrowhead Electrical Cooperative
  http://www.aecimn.com/wp-content/uploads/2013/02/GSHP-Geothermal-2013-Rebate.pdf

- Wisconsin Focus On Energy Program:

  $650 Flat Geothermal Rebate from Participating Utilities for Retrofits

  http://www.focusonenergy.com/residential/renewable/geothermal-heat-pumps

Geothermal Heat Pump Residential Tax Incentives

Federal Income Tax Credit:

- 30% of total geothermal system cost
- Credit capped at $2,000 for 2008
- Credit unlimited for 2009 through 2016
- Can be used to offset AMT tax
- Can be combined with other tax credits
- Can be used in more than one year

Eligibility:

- Home must be located in U.S.
- Includes houses, cooperatives, condos, mobile homes
- Does not have to be your main house
- GSHP must meet Energy Star requirements
- Must be placed in service between 1/1/2008-12/31/2016

Geothermal Heat Pump Business Tax Incentives

Federal Income Tax Credit:

- 10% of total geothermal system cost
- Credit is not limited
- Can be used to offset AMT tax
- Can be used in combination with subsidized financing
- Can be used in more than one year

Accelerated Depreciation:

- 5 year MACR depreciation of entire system
- Eligible for bonus depreciation in 2009 (50% write-off in first year)

Eligibility:

- Building must be located in U.S.
- Original use begins with taxpayer
- Must be placed in service between 10/3/2008-12/31/2016
- Can be used by regulated utilities
- Must be claimed by owner of property (effects non-taxable)

2016 Geothermal Financing Programs

Center for Energy and Environment (MN)

http://mncee.org/Find-Programs/Geothermal-Financing/

Loan Terms:

- Loan amounts up to $20,000
- 4.99% fixed interest rate (5.385% Annual Percentage Rate*)
- No maximum income limit
- Terms up to 10 years
- This loan is secured by a mortgage on the property. Closing costs apply

Property Eligibility:

- Single family, owner-occupied, primary residence
- Properties under construction or held in Trust are not eligible

Types of Improvements:

- Eligible improvements include: ground source heat pumps that meet or exceed Energy Star 1 efficiency requirements; heat pump water heaters and air source heat pumps that are Energy Star qualified

*APR is based on $20,000 for 10 years.

2016 Geothermal Financing Programs

CEE Loans Sponsored by Utility Partners

http://www.mnbrighterideas.com/financing/cee.cfm

Loan Terms:

- Loan amounts up to $7,500 and up to $25,000 at…
- 0% - 2.9% financing respectively!
- No family income limits
- Terms up to 10 years
- Loans must be secured via a mortgage against the property not to exceed $25,000 or up to 100 percent of the property value

Property Eligibility:

- Dwelling must be a residential, one-unit, owner-occupied property
- Member must be in good standing with the utility

Types of Improvements:

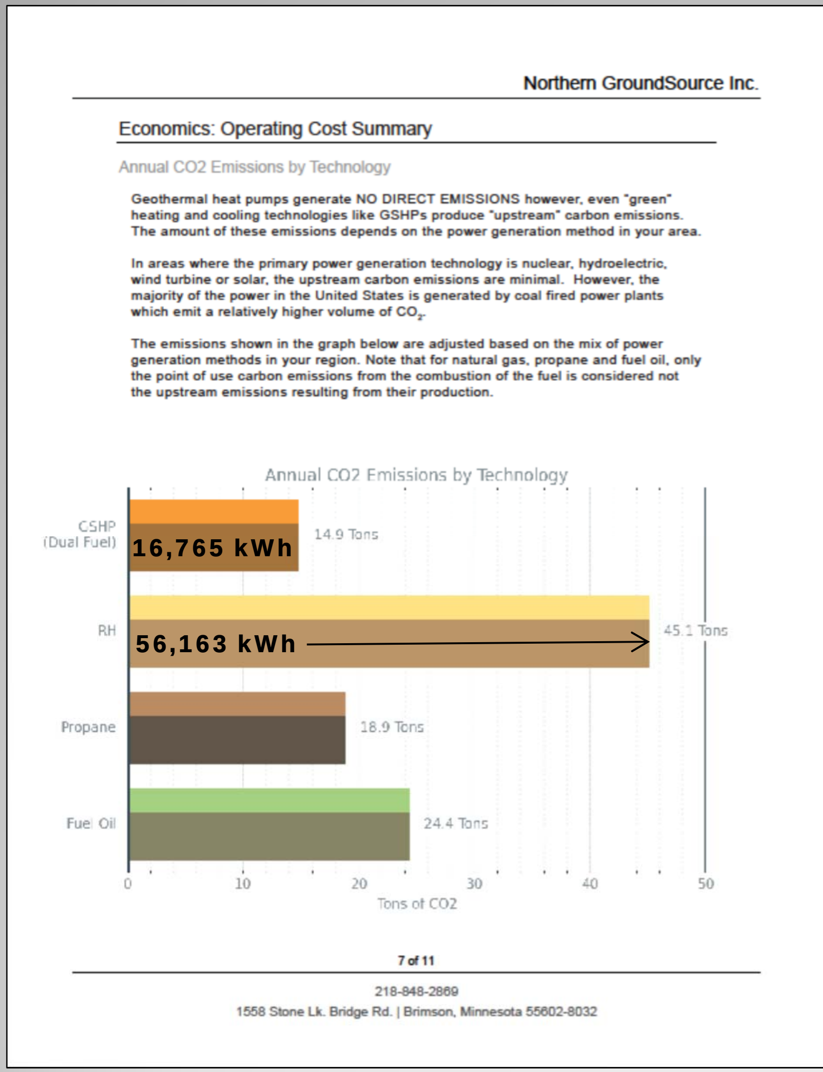
- Eligible improvements include: ground source heat pumps that meet or exceed Energy Star 1 efficiency requirements; heat pump water heaters and air source heat pumps that are Energy Star qualified; electric thermal storage (ETS) space and water heating systems with some restrictions.

➢ Quality of Equipment

➢ Quality of Installation

3. What Determines GHP System Benefit?

Examining the main factors that determine GHP economic benefit.


Northern GroundSource Inc.

Economics: Operating Cost Summary

Annual CO2 Emissions by Technology

Geothermal heat pumps generate NO DIRECT EMISSIONS however, even "green" heating and cooling technologies like GSHPs produce "upstream" carbon emissions. The amount of these emissions depends on the power generation method in your area.

In areas where the primary power generation technology is nuclear, hydroelectric, wind turbine or solar, the upstream carbon emissions are minimal. However, the majority of the power in the United States is generated by coal fired power plants which emit a relatively higher volume of CO_2.

The emissions shown in the graph below are adjusted based on the mix of power generation methods in your region. Note that for natural gas, propane and fuel oil, only the point of use carbon emissions from the combustion of the fuel is considered not the upstream emissions resulting from their production.

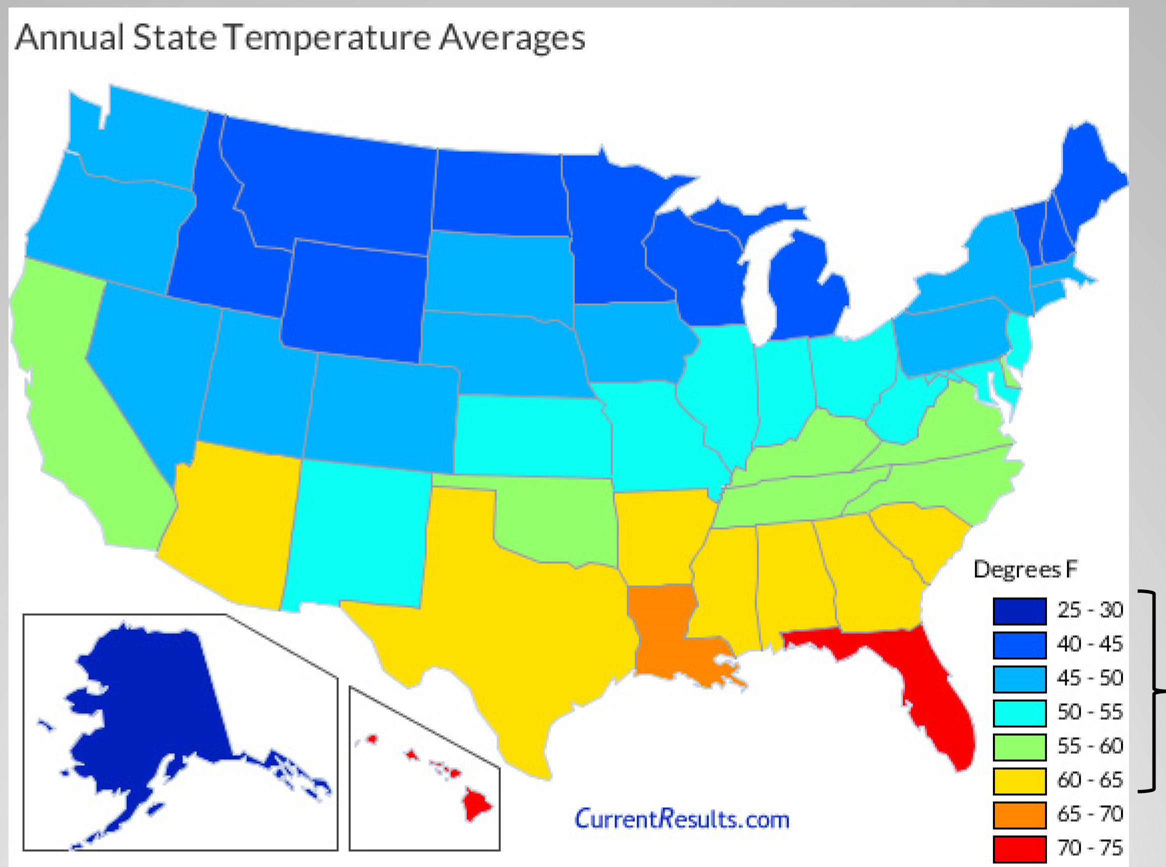
7 of 11

218-848-2869
1558 Stone Lk. Bridge Rd. | Brimson, Minnesota 55602-8032

GHP Benefits Determined By:

- Climate (Moderate vs Extreme)
- Current Energy Rates & Inflation
- GHP Capacity to Peak Load
- Adequacy of HVAC Distribution
- System Life Cycle
- Warranty & Service Distance
- Alternative Equipment Cost
- Loan Interest
- GHP System Cost Recovery

➢ Climate Moderate *vs* Extreme



Source: U.S. National Oceanic & Atmospheric Administration (NOAA).

➢ Climate Moderate *vs* Extreme

STATE	AVERAGE TEMP (2014)	U.S. RANK (2014)
ALASKA	30.1° F	49
MINNESOTA	38.6° F	48
NORTH DAKOTA	39.0° F	47
WISCONSIN	40.2° F	46

How we use energy in our homes. Heating accounts for the biggest portion of your utility bills. Source: U.S. Energy Information Administration, AEO2014.

➢ Climate Moderate *vs* Extreme

DULUTH INTL AP, ST. LOUIS COUNTY, MINNESOTA USA

Located at *about* 46.83°N 92.18°W. Height *about* 435m / 1427 feet above sea level.

Source: derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990.

Heating Degree Days **9,817**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	998	820	699	440	247	94	33	62	182	366	610	898	5454
°F	1796	1476	1258	792	445	169	59	112	328	659	1098	1616	9817

Cooling Degree Days **180**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	0	0	0	0	0	7	52	40	0	0	0	0	100
°F	0	0	0	0	0	13	94	72	0	0	0	0	180

➢ Current Energy Rates…

Energy Prices (Heating Months)

Standard Electric Rate	0.050 $/kWh	Natural Gas Rate	0.000 $/ccf
ASHP Electric Rate	0.000 $/kWh	Propane Rate	2.899 $/gal
GSHP Electric Rate	0.060 $/kWh	Fuel Oil Rate	3.899 $/gal

Energy Prices (Cooling Months)

Standard Electric Rate	0.130 $/kWh
ASHP Electric Rate	0.000 $/kWh
GSHP Electric Rate	0.130 $/kWh

➢ …and Inflation

FUEL PRICE INFLATION

Fuel Type	Range in Years	Average Yearly Increase (EIA)	Average Yearly Increase (BLS)	Range in Years	Average Yearly Increase (BLS)	Starting price (EIA)	Ending Price (EIA)	Price per
Natural Gas	1967-2010	5.54%	N/A	1979-2011*	4.08%	$1.04 (1967)	$11.20 (2010)	1,000 cu ft
Electricity	1990-2009	2.05%	2.30%	1979-2010*	3.13%	$0.078 (1990)	$0.115 (2009)	KWH
Propane	1991-2010	5.60%	N/A	N/A	N/A	$0.92 (1991)	$2.59 (2010)	gallon
#2 Heating Oil	1991-2010	5.54%	5.71%^	1979-2010*	4.59%	$1.07 (1991)	$3.00 (2010)	gallon
Unleaded Gas	1990-2010*	3.87%	4.46%	1976-2011*	5.12%	$1.30 (1990)	$2.78 (2010)	gallon
CPI**	1990-2011*	N/A	2.64%	1913-2011*	3.24%			

Range in years determined by available data

Values for US residential average nation wide

Sources: EIA (U.S. Energy Information Administration), BLS (Bureau of Labor and Statistics)

** 2011 data up to current available*

*** CPI (Consumer price index)*

^ #2 Fuel Oil

➢ GHP Capacity to Peak Load

➢ GHP Capacity to Peak Load

Heating **(Peak Load = 73,182 BTUH @ -20°F OAT / 70°F)**

Heating Capacity	74,200 Btu/hr
% Sizing	101.4%
% Energy From Geo	96.3%
Installed COP	3.25
Balance Point Temp.	-19.9 °F

➢ GHP Capacity to Peak Load

Heating (Peak Load = 73,182 BTUH @ -20°F OAT / 70°F)

Heat Pump Energy Use	15,003 kWh
Pumping Energy Use	529 kWh
Supplemental Energy Use	0 kWh
Dual Fuel Energy Use	79 gal

➢ GHP Capacity to Peak Load

Heating (IDF @ 0.06 $/kWh w/LP Backup @ $2.899/gal)

HP Cost	$900.23
Supplemental Cost	$0.00
Dual Fuel Cost	$232.29
Pumping Cost	$31.74
Total Cost	$1,164.26

- Cooling-Dominant Derived Rule: *Do not size GHP heating capacity more than 25% above the cooling load (impractical?)*
- Manufacturer-Derived Rule: *Do not size GHP to less than 85% of the peak heating load (roughly 1 Ton undersizing)*
- Cold Climate Sizing Trend: *Size to perform 96-100% of all the heating (but consider sizing scale-back for honest "hardships")*

GSHP Sizing Rules of Thumb

4.0<7T Vertically Bored GHP System @ 62.2% GHP Sizing

➢ GHP Capacity to Peak Load

Heating (Peak Load = 73,167 BTUH @ -20°F OAT / 70°F)

Heating Capacity	45,509 Btu/hr
% Sizing	62.2%
Installed COP	3.71
Balance Point Temp.	10.4 °F

➢ GHP Capacity to Peak Load

Heating (Peak Load = 73,167 BTUH @ -20°F OAT / 70°F)

Heat Pump Energy Use	12,504 kWh
Pumping Energy Use	847 kWh
Supplemental Energy Use	3,272 kWh
Dual Fuel Energy Use	0 gal

➢ GHP Capacity to Peak Load

Heating (Full Residential Electric Rate @ 0.120 $/kWh)

HP Cost	$1,500.57
Supplemental Cost	$392.66
Dual Fuel Cost	$0.00
Pumping Cost	$101.70
Total Cost	$1,994.93

➢ Adequacy of Distribution

➢ Adequacy of Distribution

- Low-temp GHP (refrigeration) technology likes to maintain system balance <u>without</u> being called on to perform extreme tasks

- Sufficient and adequately distributed air flow is <u>vital</u> for comfort, as well as proper air coil performance and heat exchange

- Continuous low speed ECM fan is extremely beneficial for air quality, efficiency and <u>comfort</u>!

➢ System Life Cycle

- **With the newer GHP technologies, most manufacturers now project a design life 25 to 30 years…<u>if</u> the GHP system is properly designed, installed and maintained**
- **EPA life cycle rating for geothermal HDPE pipe is 200 years**
- **Life cycle varies for secondary components, such as circulating pumps, blowers and some electrical parts**

➢ Warranty & Service Distance

- To meet Energy Star Tier 3 standards, the EPA now requires GHP manufacturers to warranty <u>all</u> parts and labor for 5 years

- Many manufacturers also offer an additional 5 years for refrigeration parts only (without labor) and/or "lifetime" compressor

- Because GHP technology is specialized, non-warranty service work can cost more, and a qualified technician may not be close by

➢ Alternative Equipment Cost

- **Alternative equipment is the heating and cooling equipment that would <u>otherwise</u> be installed at lesser cost (furnace, boiler, AC)**

- **Conventional HVAC equipment costs vary widely, but there is ultimately some <u>net difference</u> in cost to upgrade to geo'**

- **GHP system cost recovery calculations <u>must</u> consider alternative equipment costs for a <u>true</u> assessment of GHP economic benefit!**

➢ Alternative Equipment Cost

How much <u>more</u> is a GHP system <u>compared</u> to the alternative?

➢ Alternative Equipment Cost

Resistance Heat w/ Central A/C		GSHP	
Installation Cost	$17,421.00	Installation Cost	$39,987.00
Incentives	$0.00	Incentives	$14,306.00
Actual Cost	$17,421.00	Actual Cost	$25,681.00

Cost difference between RH Thermal Storage & 7T GHP system

➢ Interest

Resistance Heat w/ Central A/C		GSHP	
Installation Cost	$17,421.00	Installation Cost	$39,987.00
Incentives	$0.00	Incentives	$14,306.00
Actual Cost	$17,421.00	Actual Cost	$25,681.00
Loan Amount	$17,421.00	Loan Amount	$25,681.00
Loan Interest Rate	3.900%	Loan Interest Rate	3.900%
Loan Term	20 years	Loan Term	20 years
Down Payment	$0.00	Down Payment	$0.00
Monthly Payment (P&I only)	$104.65	Monthly Payment (P&I only)	$154.27

Cost difference between RH Thermal Storage & 7T GHP system

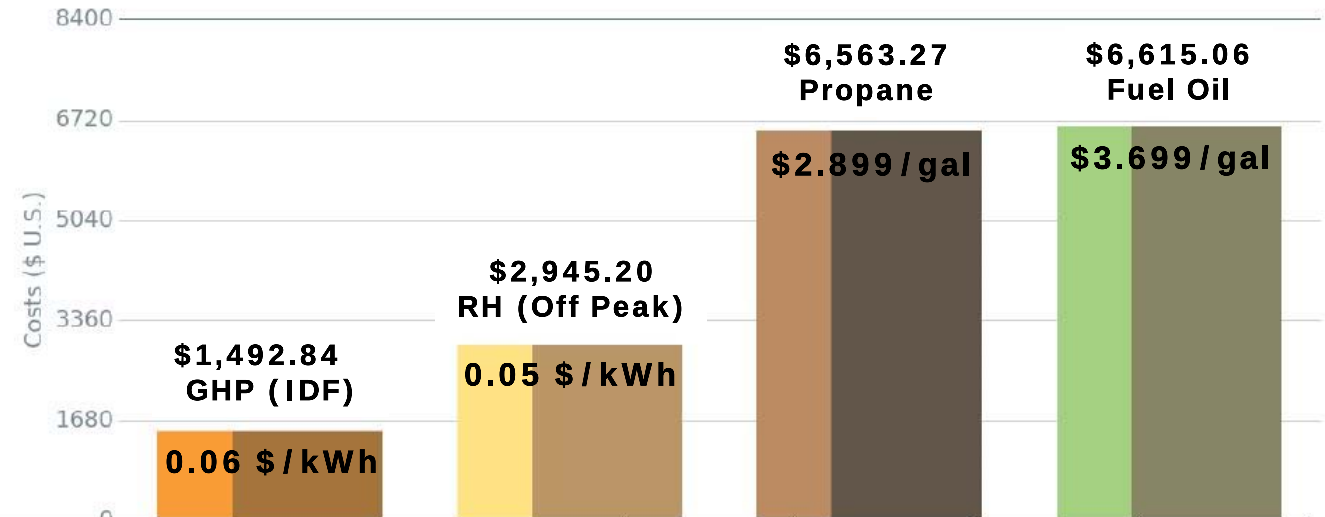
➤ GHP System Cost Recovery

- **SIMPLE PAYBACK**—how long it takes for the net upgrade cost of the GHP system to be fully recovered using current energy rates

- **SHORT TERM SAVINGS**—snapshot of annual and monthly savings with incremental loan interest taken into account

- **30 YEAR SAVINGS**—difference in cost of ownership between a conventional HVAC system and GHP system over 30 years

SIMPLE PAYBACK



System Type	Heating	Cooling	Hot Water	Total	vs. GSHP
Ground Source Heat Pump (GSHP)	$1,164.26	$160.42	$168.17	$1,492.84	———
RH	$2,567.85	$150.83	$226.52	$2,945.20	$1,452.36
Propane	$6,185.92	$150.83	$226.52	$6,563.27	$5,070.43
Fuel Oil	$6,237.71	$150.83	$226.52	$6,615.06	$5,122.22

SIMPLE PAYBACK

Simple Payback

GSHP Install Cost	$25,681.00	−	Conventional Install Cost	$17,421.00
Conventional Operating Cost	$2,945.20	−	GSHP Operating Cost	$1,492.84

$$\Rightarrow \frac{\$8,260.00}{\$1,452.36} = \text{Simple Payback Period } 5.7 \text{ years}$$

SHORT TERM SAVINGS

Short Term Savings

Monthly Operating Savings

Conventional Op. Cost	$245.43
− GSHP Op. Cost	$124.40
Monthly Op. Savings	$121.03

Difference in Monthly Payment

Payment w/ GSHP	$154.27
− Payment w/ Conv.	$104.65
Incremental Payment	$49.62

Monthly Operating Savings $121.03 − Incremental Payment $49.62

= Monthly Savings w/ GSHP $71.41

Monthly Savings w/ GSHP $71.41 × 12 = Annual Savings w/ GSHP $856.92

30 YEAR SAVINGS

30 Year Savings

Resistance Heat w/ Central A/C

Adjusted Install Price	$25,116.51
+ Adjusted Op. Cost	$140,119.11
Ownership Cost	$165,235.62

GSHP

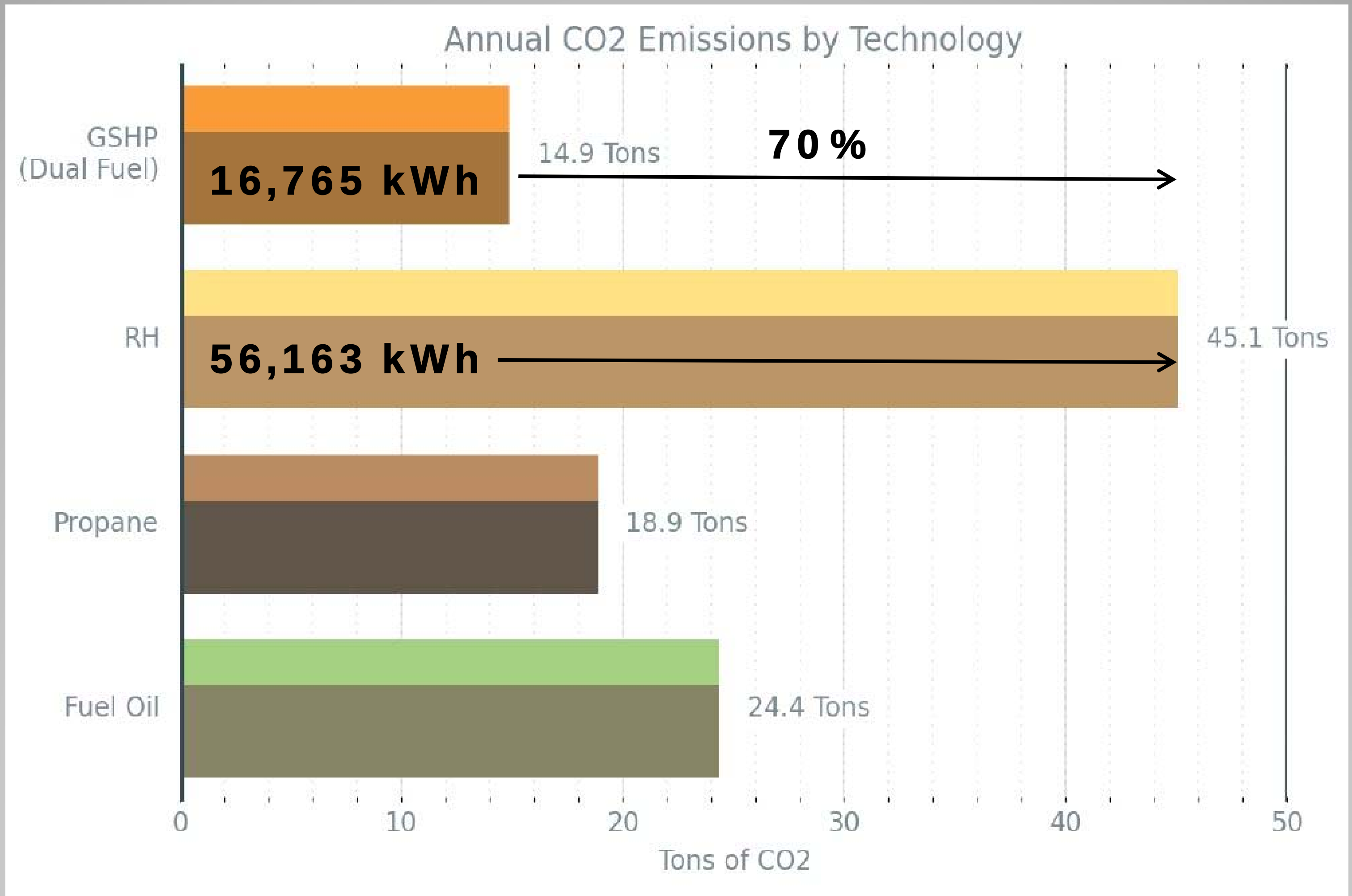
Adjusted Install Price	$37,025.26
+ Adjusted Op. Cost	$71,022.96
Ownership Cost	$108,048.22

Conventional Ownership Cost $165,235.62 − GSHP Ownership Cost $108,048.22

= 30 Year Savings $57,187.40

LIFETIME SAVINGS!

Over 70% of home's heating energy needs will be FREE forever.



DON'T FORGET…ENVIRONMENTAL "SAVINGS"

RESOURCES:

- Northern GroundSource Inc.
  www.ColdClimateGeothermal.com
- International Ground Source Heat Pump Association
  www.igshpa.okstate.edu
- Minnesota Geothermal Heat Pump Association
  www.MNGHPA.org
- Wisconsin Geothermal Association
  www.wisgeo.org
- GeoExchange
  www.GeoExchange.org
- Association of Energy Engineers
  www.aeecenter.org

END