GeoSystems
Geothermal Heat Pumps

Finding the Right Fit

Balancing Loads and Capacity in a Cold Climate

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The Early days of Geothermal Heat Pumps

Geothermal heat pumps were originally designed for use in warm climates for cooling, with the following features:

- Larger cooling capacities
- Smaller heating capacities
- Longer run times when dehumidifying

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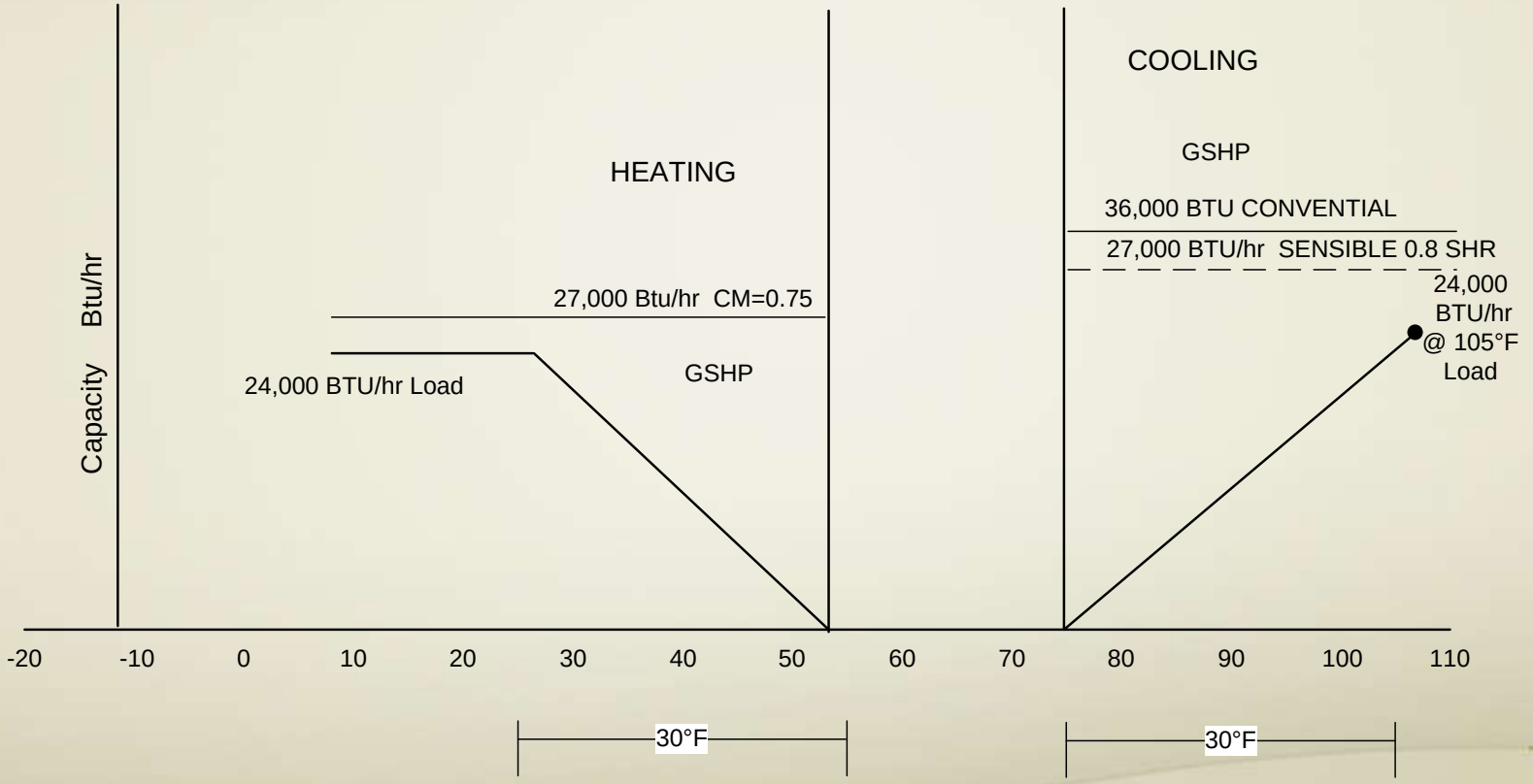
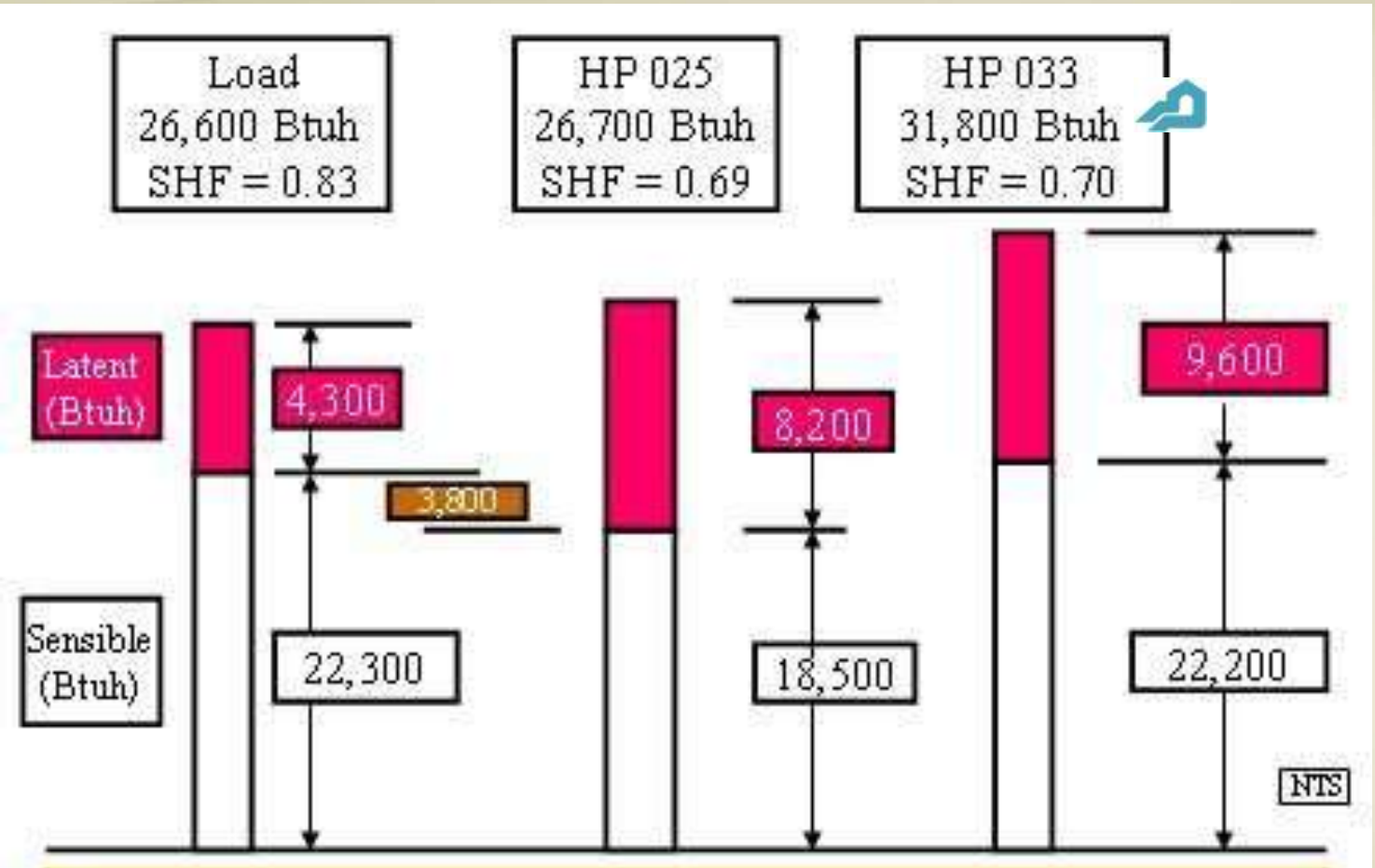
Original heat pump sized for warm climates



Traditional Heat Pump Sizing Rule

- The SHF for the unit must be less than or equal to the SHF for the space.
- The cooling unit should be sized based on the sensible cooling load for the space and the sensible cooling capacity of the unit.
- The latent requirement must be satisfied.



Heat Pump Sizing

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Welcome to the Great White North!

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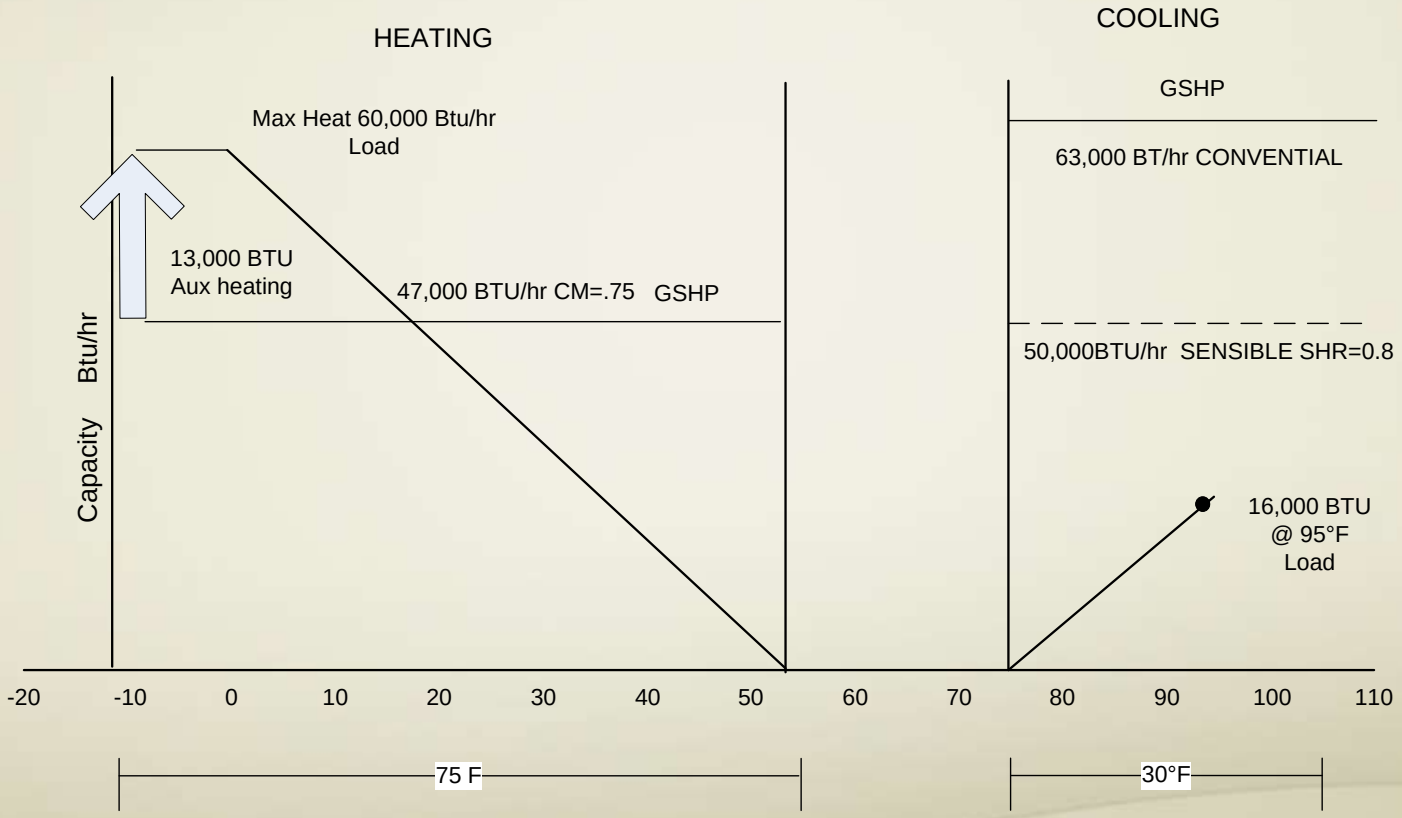
In order to meet the large heating requirements in cold climates, geothermal heat pumps became grossly oversized in cooling.



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Blower Speed & Duct Specifications

Table 3 - Duct Sizing Chart

	Acceptable Branch Duct Sizes		Acceptable Main or Trunk Duct Sizes	
CFM	Round	Rectangular	Round	Rectangular
50	4"	4x4		
75	5"	4x5, 4x6		
100	6"	4x8, 4x6		
150	7"	4x10, 5x8, 6x6		
200	8"	5x10, 6x8, 4x14, 7x7		
250	9"	6x10, 8x8, 4x16		
300	10"	6x14, 8x10, 7x12		
350	10"	6x20, 6x16, 9x10		
400	12"	6x18, 10x10, 9x12	10"	4x20, 7x10, 6x12, 8x9
450	12"	6x20, 8x14, 9x12, 10x11	10"	5x20, 6x16, 9x10, 8x12
500			10"	10x10, 6x18, 8x12, 7x14
600			12"	6x20, 7x18, 8x16, 10x12
800			12"	8x18, 9x15, 10x14, 12x12
1000			14"	10x18, 12x14, 8x24
1200			16"	10x20, 12x18, 14x15
1400			16"	10x25, 12x20, 14x18, 15x16
1600			18"	10x30, 15x18, 14x20
1800			20"	10x35, 15x20, 16x19, 12x30, 14x25
2000			20"	10x40, 12x30, 15x25, 18x20

20 X

Current 5T

Tables calculated for 0.05 to 0.10 inches of water friction per 100' of duct. At these duct design conditions, along with the pressure drop through the filter, the total design external static pressure is 0.20 inches of water.

Table 4 – Blower Speed Settings

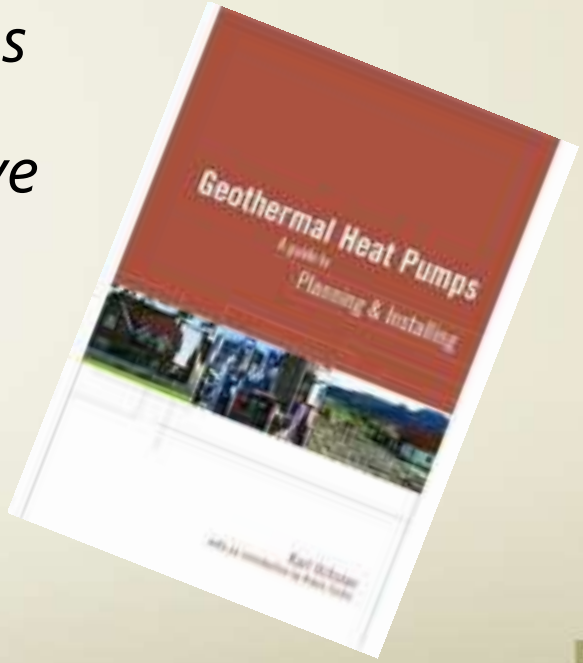
TAP	Low (G)	Medium-Low (Y)	Medium-High (Y2)	High (W2/E)
A (68 Series)	990	1730	2250	2400
B (58 Series)	815	1425	1850	1920
C (48 Series)	740	1295	1680	1800
D (38 Series)	520	910	1180	1300

Note: Adjust Tap set to "+" will increase these numbers by 10%
Adjust Tap set to "-" will decrease these numbers by 10%

GSHP Sizing Rule of Thumb

<u>Cooling-Dominant Derived Rule</u>:

Do not size Ground Source Heat Pumps heating capacity more than 25% above the cooling load.



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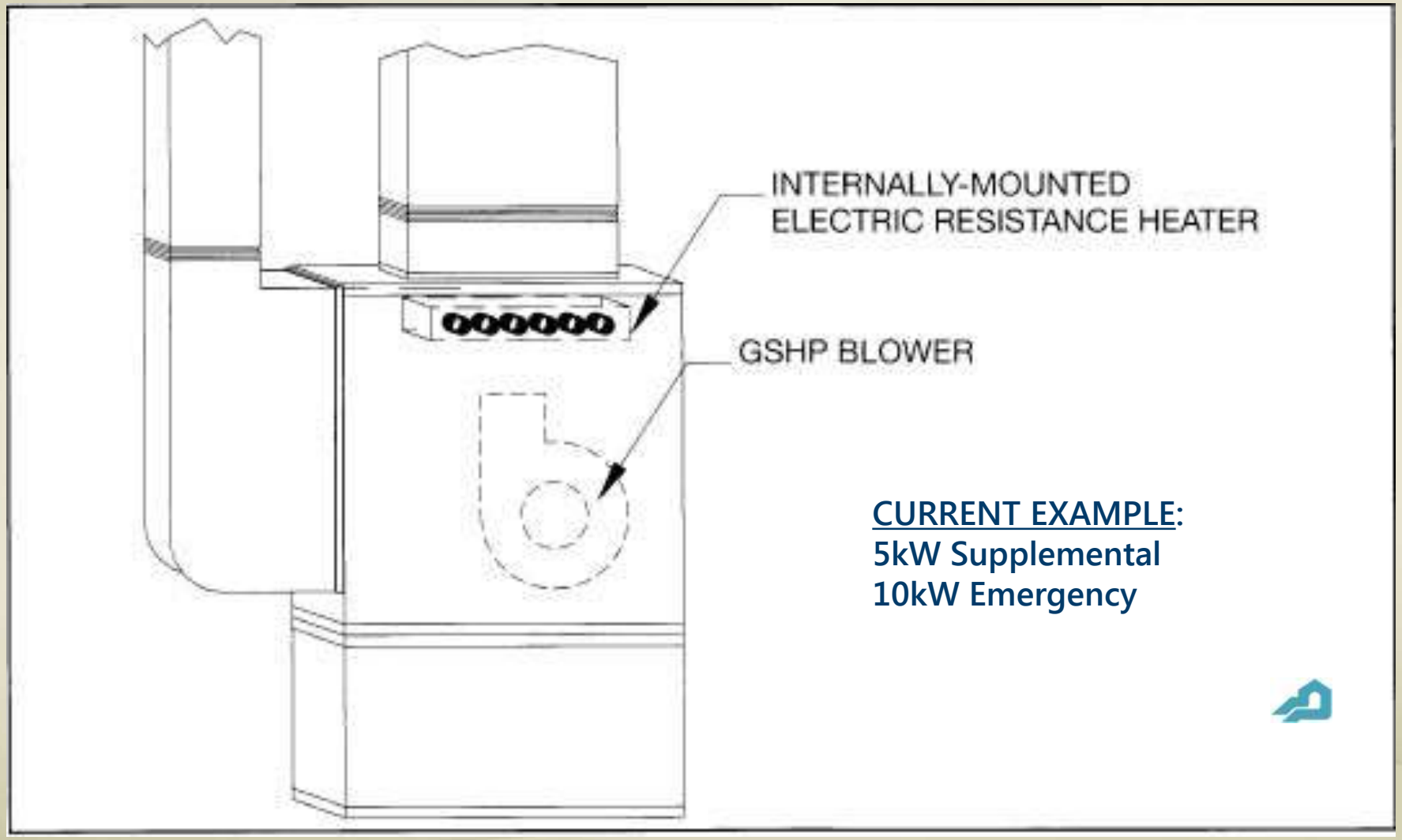
Auxiliary Electric Resistant Heat…An Easy Solution



CURRENT EXAMPLE:
5kW Supplemental
10kW Emergency

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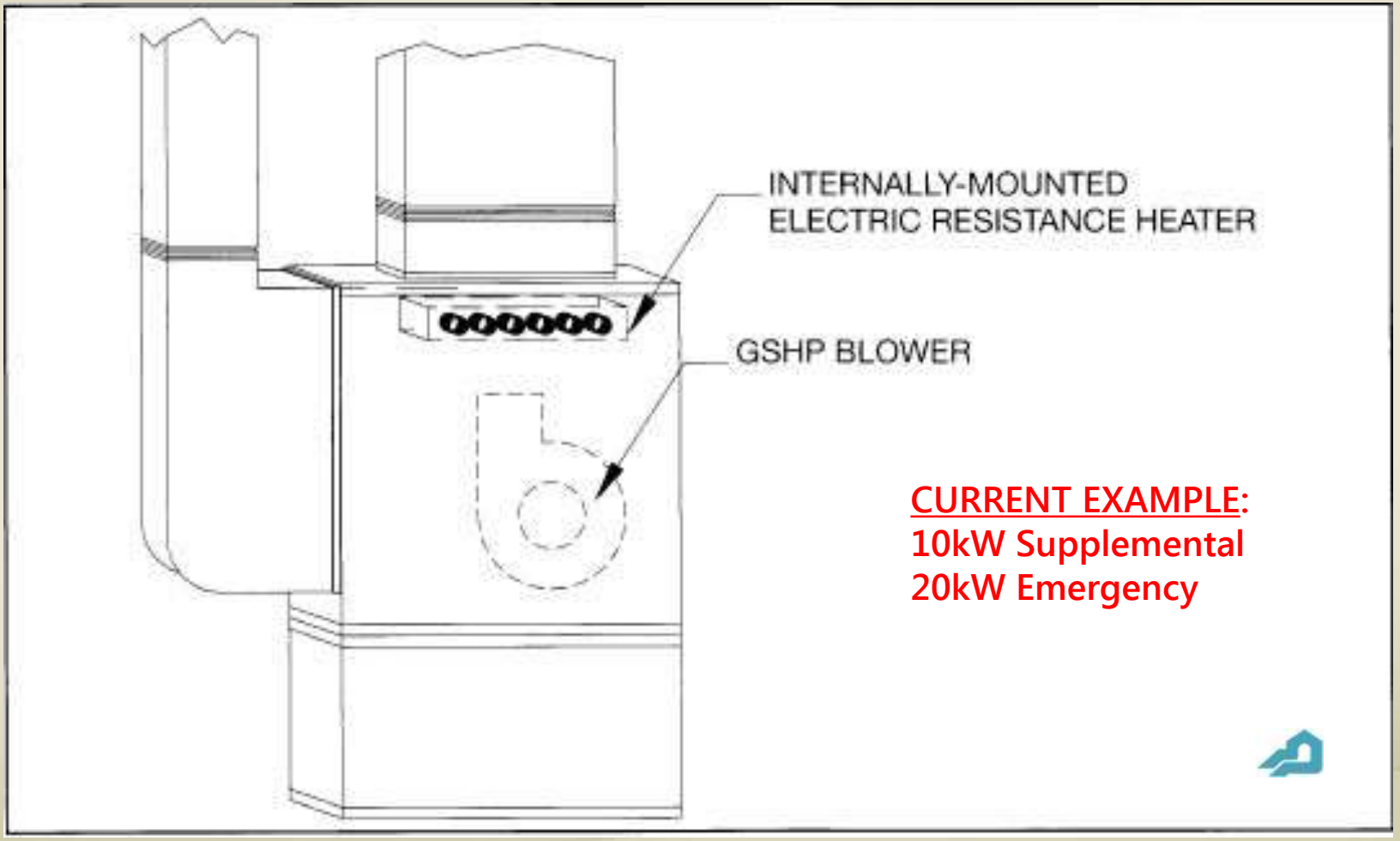
GSHP Systems Started Getting Smaller Again…Sacrificing Efficiency!



CURRENT EXAMPLE:
10kW Supplemental
20kW Emergency

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New Goal: "Cold Climate Technology"

The ability to provide as close to 100%

of a home's heating needs without

sacrificing air conditioning comfort.

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Properly Sizing for Cold Climates

- More balanced heating and cooling capacity
- Long enough run times to ensure proper de-humidification
- Air coils with greater latent energy removal
- Water loop heat exchangers that maximize capacity and lower pressure drop
- Optimization of refrigerant for both heating and cooling

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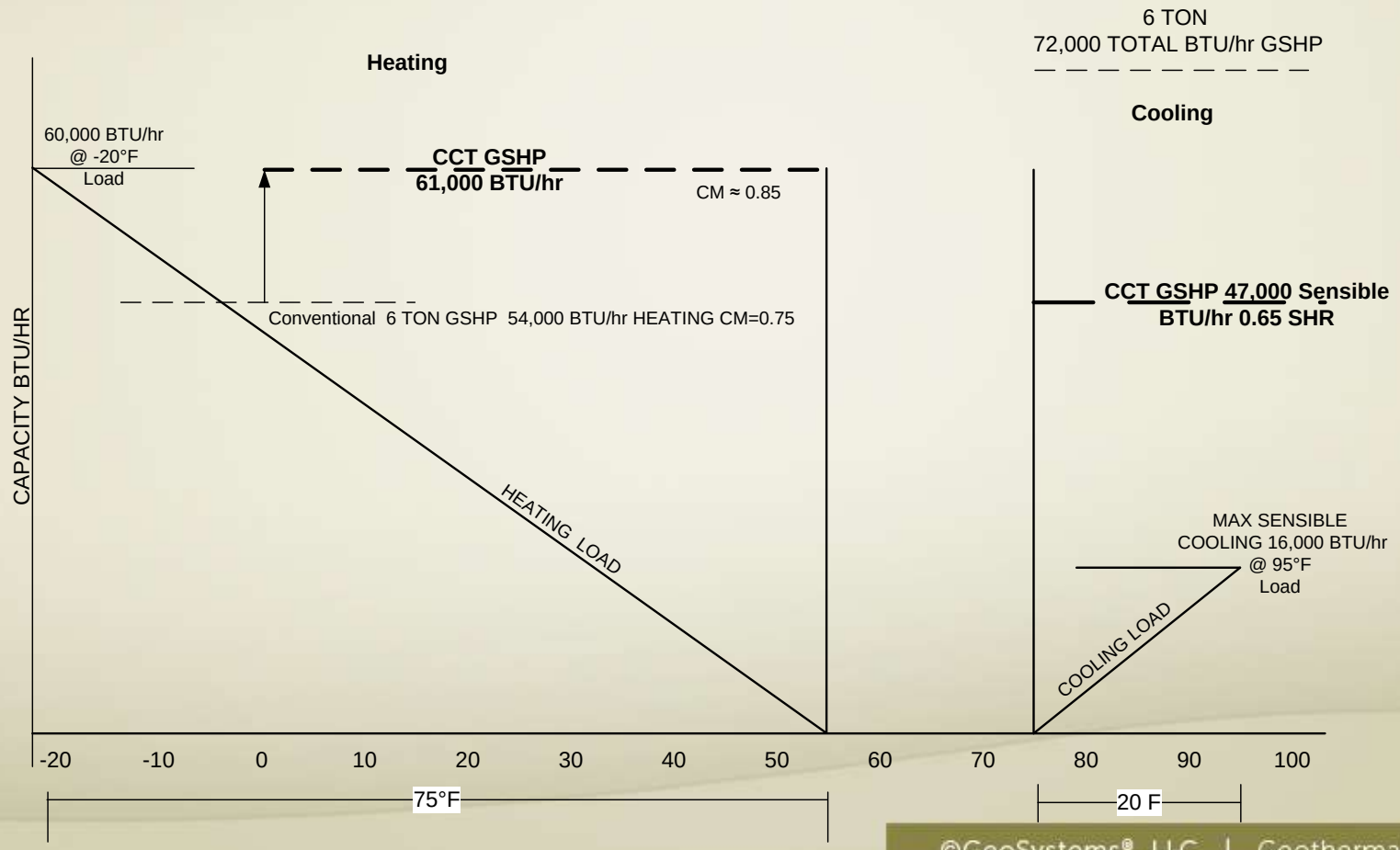
Properly Sizing for Cold Climates



New Energy Star Requirements Forced Many New Changes in GSHP Technologies!

IRS Form 5695

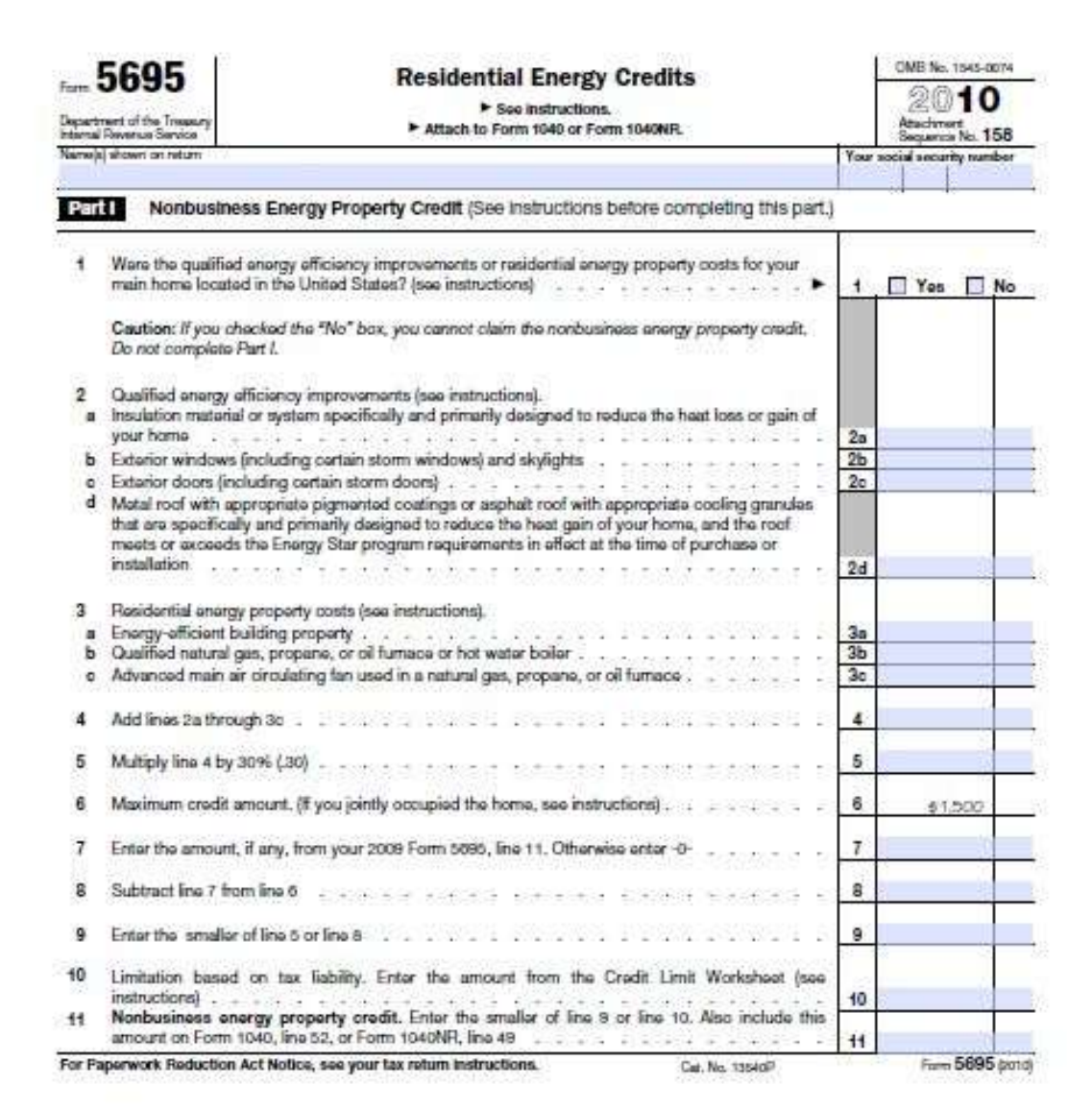
www.irs.gov/pub/irs-pdf/f**5695**.pdf

Practical Interpretation:

Cost of anything-and-everything that you have to do up to-and-beyond what you would have to do otherwise you can't do the Geo'.

Benefit:

30% uncapped tax credit applies directly to income tax for any year through 2016.



Form **5695** — Residential Energy Credits

Department of the Treasury, Internal Revenue Service

► See instructions.

► Attach to Form 1040 or Form 1040NR.

OMB No. 1545-0074

2010

Attachment Sequence No. 158

Name(s) shown on return | Your social security number

Part I Nonbusiness Energy Property Credit (See instructions before completing this part.)

1	Were the qualified energy efficiency improvements or residential energy property costs for your main home located in the United States? (see instructions) ►	1	☐ Yes ☐ No
	Caution: *If you checked the "No" box, you cannot claim the nonbusiness energy property credit. Do not complete Part I.*		
2	Qualified energy efficiency improvements (see instructions).		
a	Insulation material or system specifically and primarily designed to reduce the heat loss or gain of your home	2a	
b	Exterior windows (including certain storm windows) and skylights	2b	
c	Exterior doors (including certain storm doors)	2c	
d	Metal roof with appropriate pigmented coatings or asphalt roof with appropriate cooling granules that are specifically and primarily designed to reduce the heat gain of your home, and the roof meets or exceeds the Energy Star program requirements in effect at the time of purchase or installation	2d	
3	Residential energy property costs (see instructions).		
a	Energy-efficient building property	3a	
b	Qualified natural gas, propane, or oil furnace or hot water boiler	3b	
c	Advanced main air circulating fan used in a natural gas, propane, or oil furnace	3c	
4	Add lines 2a through 3c	4	
5	Multiply line 4 by 30% (.30)	5	
6	Maximum credit amount. (If you jointly occupied the home, see instructions)	6	$1,500
7	Enter the amount, if any, from your 2009 Form 5695, line 11. Otherwise enter -0-	7	
8	Subtract line 7 from line 6	8	
9	Enter the smaller of line 5 or line 8	9	
10	Limitation based on tax liability. Enter the amount from the Credit Limit Worksheet (see instructions)	10	
11	**Nonbusiness energy property credit.** Enter the smaller of line 9 or line 10. Also include this amount on Form 1040, line 52, or Form 1040NR, line 49	11	

For Paperwork Reduction Act Notice, see your tax return instructions. Cat. No. 13540P Form **5695** (2010)

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New Technologies Are Developed!

Now, we are able to size units with minimal to no auxiliary heating, AND *properly* size in order to take full advantage of the greater capacity of the cold climate designed equipment… Not to mention, continue expanding the remarkable efficiencies and cost-effectiveness of geothermal heat pumps over conventional systems.

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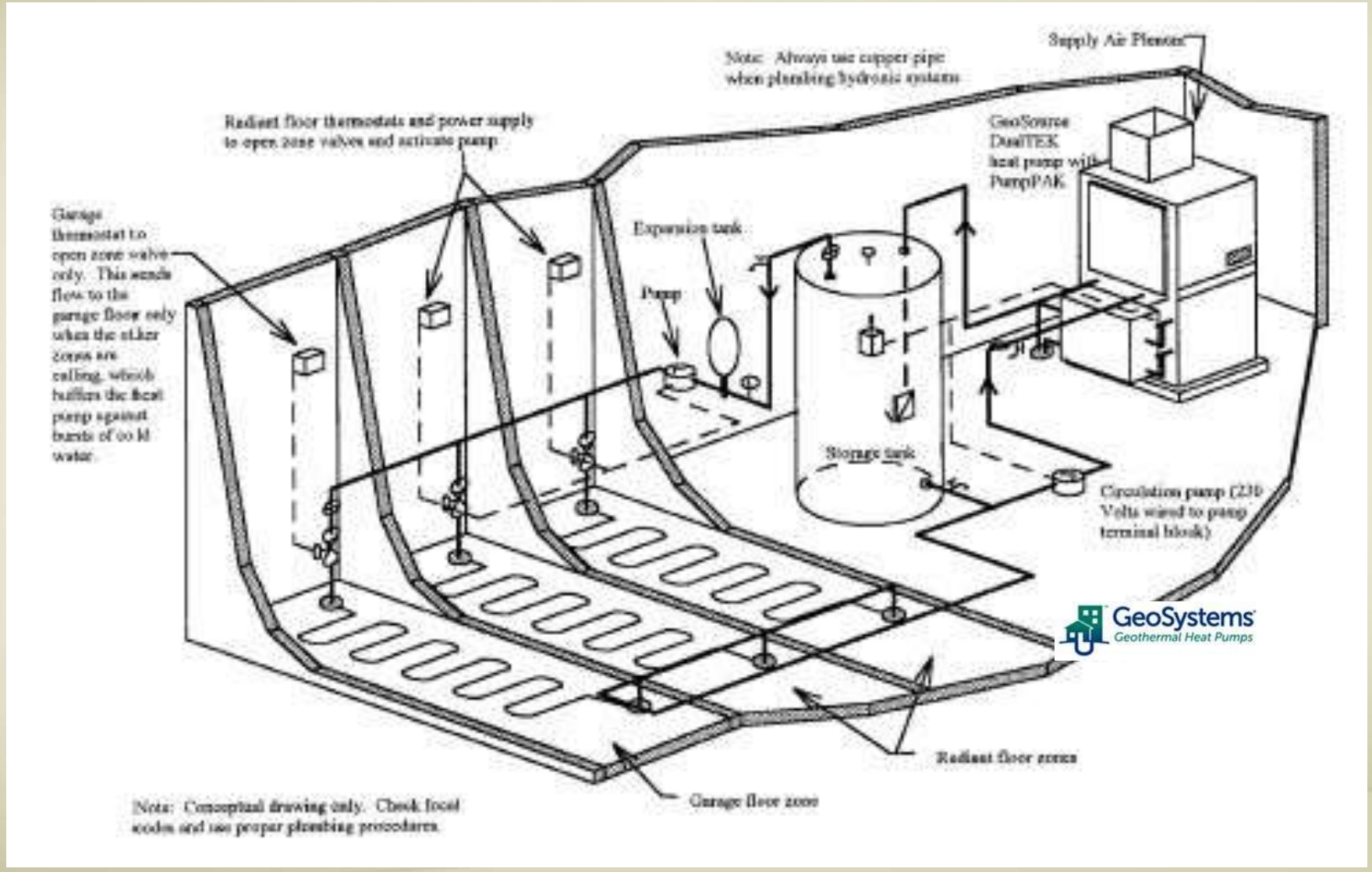
Combined Forced Air/Hydronic GSHP



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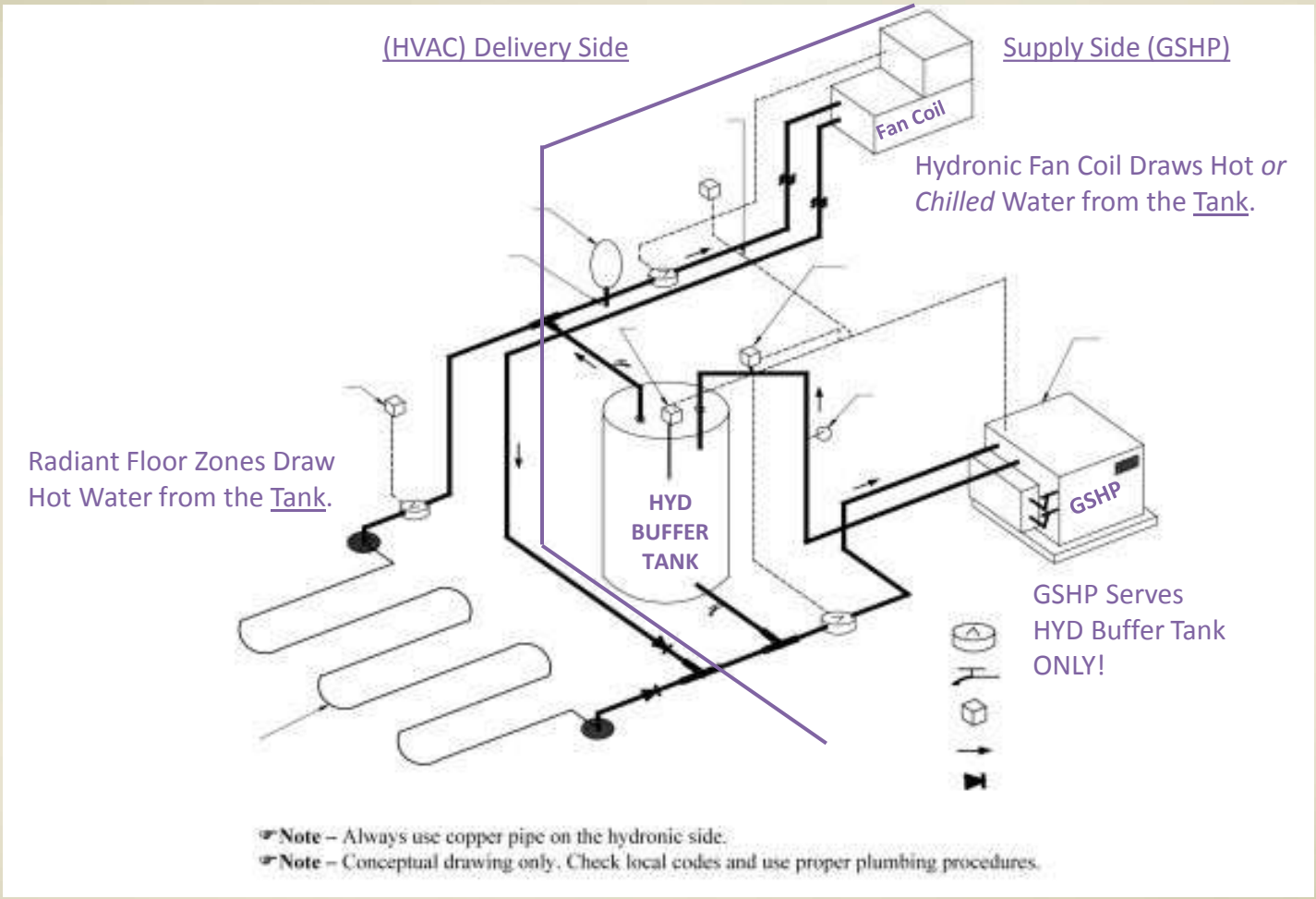
"Combo" GSHP: Forced Air HT/CL & HYD "Heat Only" (w/ Sidearm Dual Fuel Boiler)

Hydronic Heat/Cool GSHP System



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5 T HYD GSHP w/ 3 T HYD Fan Coil combines radiant floor heating with F/A heating & cooling

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New Technologies Continue to Be Developed!

DULUTH HOUSE: New Construction

- DULUTH INTL AP (Bin Weather Data)
- 50,000 BTUH Heat Loss (@ -20°F OAT)
- 24,750 BTUH Heat Gain (@ +84°F OAT)
- 5 Ton 3HT/2CL Forced Air Heat Pump

3HT/2CL FORCED AIR EXAMPLE:
2,500 to 3,000 ft^2 House (Typical)

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5 Ton = 51,700 BTUH GSHP CAP @ 30F EWT

Heating (High Capacity)

Heating Capacity	51,700 Btu/hr
% Sizing	103.4%
Installed COP	3.70
Balance Point Temp.	-22.1 °F

Heating (Low Capacity)

Heating Capacity	37,700 Btu/hr
% Sizing	75.4%
Installed COP	3.95

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Cooling (High Capacity)

Total Cooling Capacity	57,500 Btu/h
Sensible Cooling Capacity	43,125 Btu/h
% Oversizing	74.2%
Installed EER	12.50

Cooling (Low Capacity)

Total Cooling Capacity	46,100 Btu/h
Sensible Cooling Capacity	34,575 Btu/h
% Oversizing	39.7%
Installed EER	14.41

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These configurations are made even easier with advances in thermostat technology.

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5T GSHP Runtime & Operating Cost

Heating

High Capacity Runtime	250 hrs
Low Capacity Runtime	2,532 hrs
Resistance Heat Runtime	31 hrs
Heat Pump Energy Use	8,445 kWh
Resistance Heat Energy Use	20 kWh
Pumping Energy Use	776 kWh

Cooling

High Capacity Runtime	0 hrs
Low Capacity Runtime	275 hrs
Heat Pump Energy Use	799 kWh
Pumping Energy Use	76 kWh

Heating

HP Operating Cost	$760.14
Resistance Heat Operating Cost	$1.83
Pumping Cost	$69.85
Total Cost	$831.82

Cooling

HP Operating Cost	$71.99
Pumping Cost	$6.91
Total Cost	$78.90

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4 Ton = 41,100 BTUH GSHP CAP @ 30F EWT

Heating (High Capacity)

Heating Capacity 41,100 Btu/hr

% Sizing 82.2%

Installed COP 3.54

Balance Point Temp. -9.5 °F

Heating (Low Capacity)

Heating Capacity 29,000 Btu/hr

% Sizing 58.0%

Installed COP 3.70

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Cooling (High Capacity)

Total Cooling Capacity 47,500 Btu/h

Sensible Cooling Capacity 35,625 Btu/h

% Oversizing 43.9%

Installed EER 12.50

Cooling (Low Capacity)

Total Cooling Capacity 37,000 Btu/h

Sensible Cooling Capacity 27,750 Btu/h

% Oversizing 12.1%

Installed EER 14.23

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4.0<5T GSHP Runtime & Operating Cost

Heating

High Capacity Runtime	607 hrs
Low Capacity Runtime	2,535 hrs
Resistance Heat Runtime	160 hrs
Heat Pump Energy Use	8,281 kWh
Resistance Heat Energy Use	291 kWh
Pumping Energy Use	724 kWh

Cooling

High Capacity Runtime	0 hrs
Low Capacity Runtime	330 hrs
Heat Pump Energy Use	787 kWh
Pumping Energy Use	76 kWh

Heating

HP Operating Cost	$745.30
Resistance Heat Operating Cost	$26.21
Pumping Cost	$65.16
Total Cost	$836.67

Cooling

HP Operating Cost	$70.83
Pumping Cost	$6.86
Total Cost	$77.69

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Geothermal Heat Pumps

51,700 BTUH GSHP CAP
$831.82 Annual Heating Cost

41,100 BTUH GSHP CAP
$836.67 Annual Heating Cost

Similar Result?…What's the Hitch?

GHEX Sizing (i.e., cost)…about the same!

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5,068 ft. Total Pipe

4,796 ft. Total Pipe

Saves Only 272 ft. of Total Pipe

(And Excavation Cost is About the Same)

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Saves 26 ft. Off Each Bore Hole
(Slightly More Savings on Drilling)

5 Ton Vertically Bored GHEX

Earth Temperature Data Location

Deep earth (below 20ft) temperature is a function of the average annual air temperature in your region and remains relatively constant regardless of season.

Deep Earth Temp (T_g) 48.0 °F

Formation Details

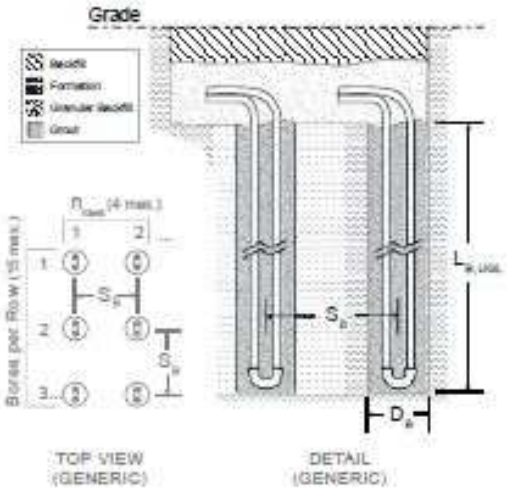
The thermal properties of your formation are based on the formation's composition and have a direct impact on the scale of your loopfield.

Thermal Conductivity 1.20 Btu/hr ft °F

GHEX Summary

Heating is dominant

Grout is used inside of all bores in order to protect the deep earth environment from surface contaminants and to provide a more effective contact surface with GHEX piping that optimizes heat transfer between the fluid pumped through your GSHP and the earth.



Grout T.C.	1.00 Btu/hr ft °F
EWT_{MIN}	30.0 °F
EWT_{MAX}	90.0 °F
Bore Diameter (D_B)	5.87 in
Pipe Diameter (D_p)	1.00 in
Bores in Series (N_{BIS})	1
Layout Rows (n_{rows})	1
Bores per Row	4
Number of Bores	4
Bore Spacing (S_B)	20.0 ft
Bore Depth (L_B)	198 ft
Adj. Bore Depth* ($L_{B,UGL}$)	250 ft
System Run Fraction	0.574

*Adj. Bore Depth is the adjusted bore depth. This is the depth of bore that should be used to accommodate unbalanced ground loads over time.

4 X 250 ft. Total Bore

5 Ton Vertically Bored GHEX

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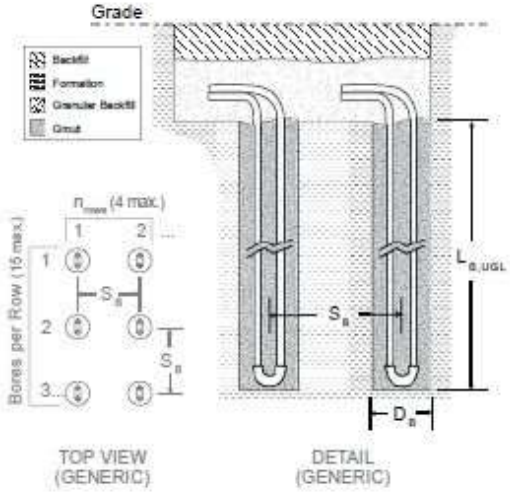

Grout T.C.	1.00 Btu/hr ft °F
EWT_{MIN}	30.0 °F
EWT_{MAX}	90.0 °F
Bore Diameter (D_B)	5.87 in
Pipe Diameter (D_p)	1.00 in
Bores in Series (N_{BIS})	1
Layout Rows (n_{rows})	1
Bores per Row	4
Number of Bores	4
Bore Spacing (S_B)	20.0 ft
Bore Depth (L_B)	171 ft
Adj. Bore Depth* ($L_{B,UGL}$)	224 ft
System Run Fraction	0.664

*Adj. Bore Depth is the adjusted bore depth. This is the depth of bore that should be used to accommodate unbalanced ground loads over time.

4 X 224 ft. Total Bore

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GSHP Sizing Rules of Thumb

- **Cooling-Dominant Derived Rule:**

  Do not size GSHP heating capacity more than 25% above the cooling load (impractical?)

- **Manufacturer-Derived Rule:**

  Do not size GSHP to less than 85% of the peak heating load (roughly 1 Ton undersizing)

- **Cold Climate Sizing Solution:**

  Size to perform 96-100% of all the heating (but consider sizing scale-back for honest "hardships")

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Welcome to the Great White North!
Any Questions?