Minnesota Geothermal Heat Pump Association 2012
Properly Sizing Ground Source Heat Pump Systems

MNGHPA
Minnesota Geothermal Heat Pump Association

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ClimateMaster

Objective

Properly Size and Select GSHP System for Low Operating Costs And Proper Control of Indoor Air Conditions

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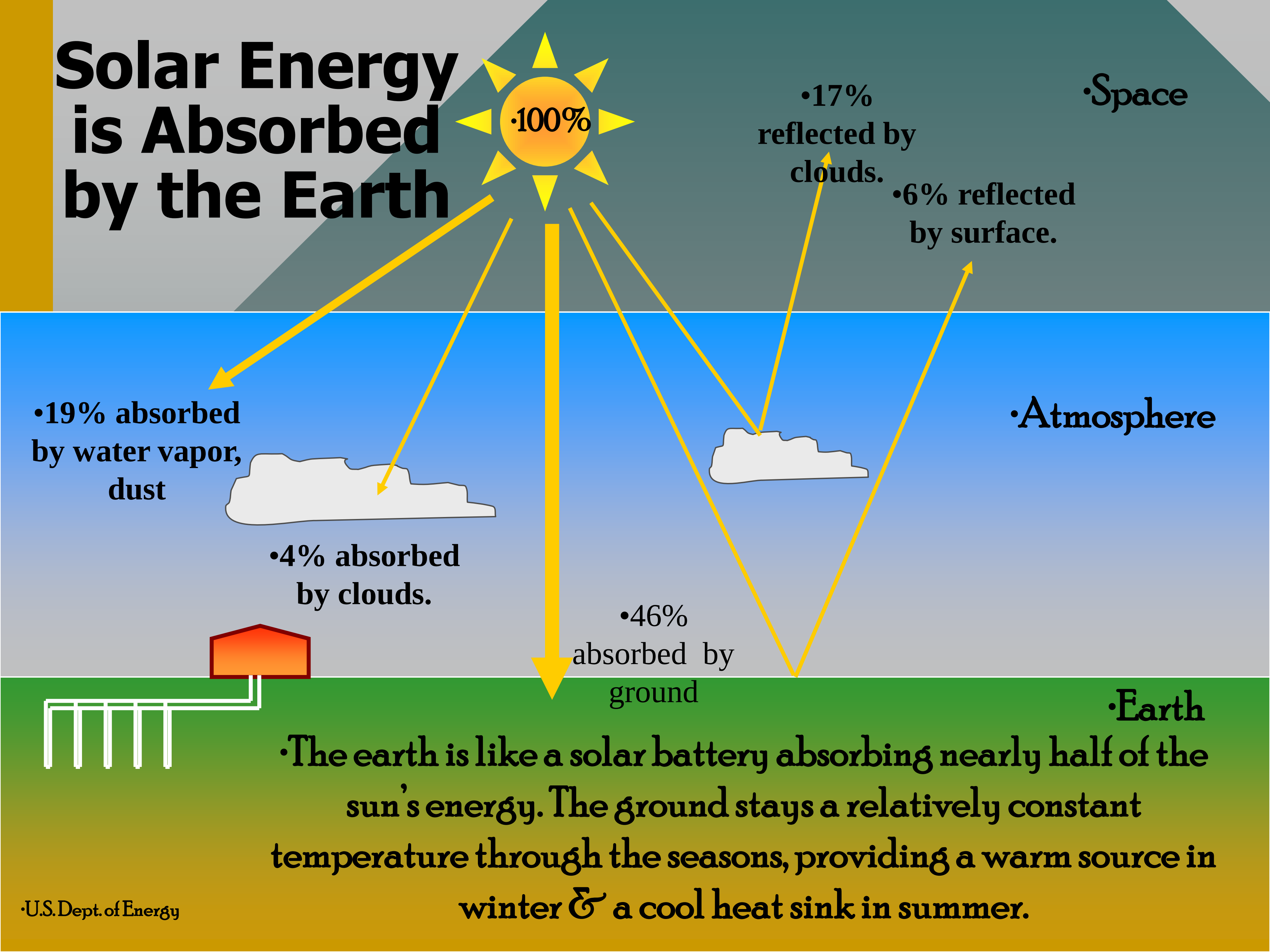
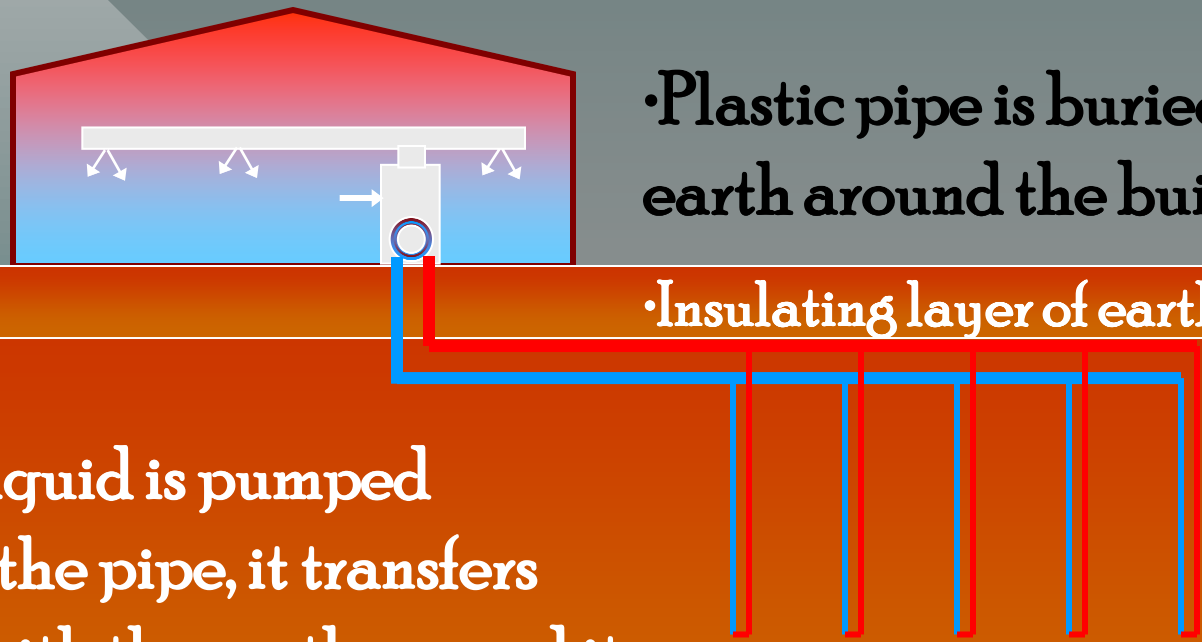

Solar Energy is Absorbed by the Earth
•100%
•17% reflected by clouds.
•6% reflected by surface.
•Space
•Atmosphere
•19% absorbed by water vapor, dust
•4% absorbed by clouds.
•46% absorbed by ground
•Earth
•The earth is like a solar battery absorbing nearly half of the sun's energy. The ground stays a relatively constant temperature through the seasons, providing a warm source in winter & a cool heat sink in summer.
•U.S. Dept. of Energy

Heat Is Transferred Through an Earth Loop



- Plastic pipe is buried in the earth around the building
- Insulating layer of earth
- When liquid is pumped through the pipe, it transfers energy with the earth around it
- 40-70°F

Sizing Procedures

Calculate Building / Zone Heating / Cooling Loads

Select Geothermal Heat Pump/s for Building / Zones

Design Ground Loop System Using a Software Program

Run Operating Costs Comparison Using a Software Program

Verify Dehumidification in Cooling Mode

Check Effects on Ground Loop System by Unit Size

Objectives: Building Loads <u>Residential</u>

Heating and cooling loads are required for each zone / area that will have a ground loop system

Residential - Manual “J” load Calculation

Room by Room loads for duct sizing & CFM

Total Zone or Building loads for Equipment Selection

Cooling Load MUST Include <u>Sensible</u> and <u>Latent</u> Loads

Objectives: Building Loads Residential

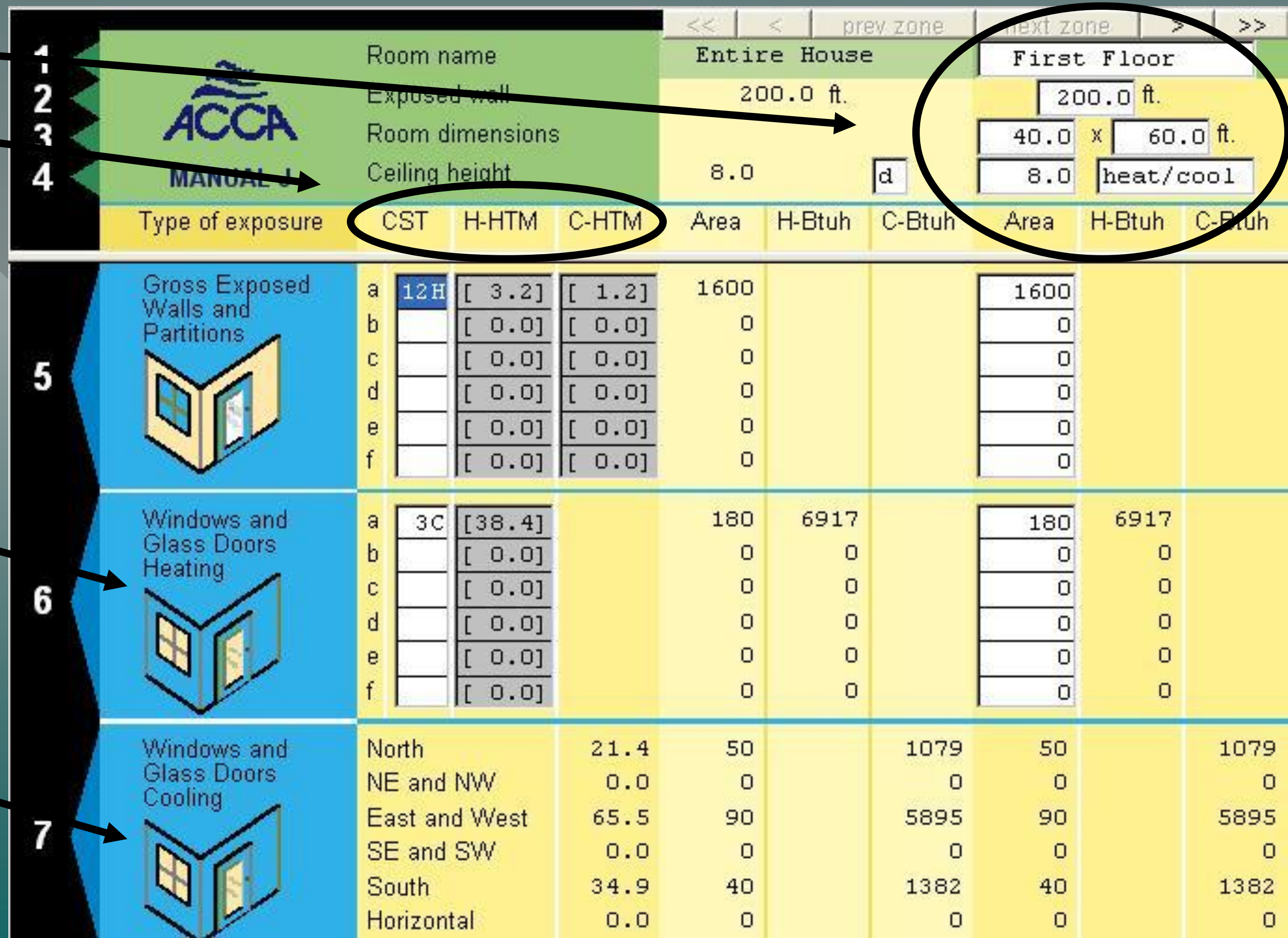
Various Software Programs to Calculate Loads

Input Data

Outside Walls

Input Windows HTG

Input Windows CLG



Objectives: Building Loads <u>Residential</u>

Windows Cooling

Select Type

Direction

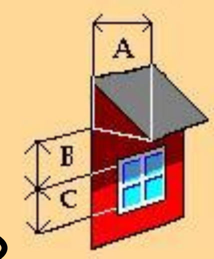
Shading

CLG HTM

Zone / room: Entire House / First Floor

Glazing CST: 3C (Metal Frame, Dbl Pane, Clear Glass)

Glazing orientation:	s	e	n	w
Glazing area (sqft):	45.0	45.0	45.0	45.0
Wall / ceiling type (see F5):	a	a	a	a
Glazing type (c, h, r):	c	c	c	c
Storms on in summer (y, n):	n	n	n	n
Inclination angle (0 - 90):	90	90	90	90
Shading type (n, d, b, s, i):	n	n	n	n
Shading coefficient (.01 - 1.0):	0.90	0.90	0.90	0.90
Overhang depth, A (ft):	1.00	1.00	1.00	1.00
Overhang to glazing distance, B (ft):	2.00	2.00	2.00	2.00
Glazing height, C (ft):	5.00	5.00	5.00	5.00
Component cooling HTM:	[34.9]	[65.5]	[21.4]	[65.5]



Note: Any overhang-shaded portion will be entered on the worksheet as facing north.

Objectives: Building Loads Residential

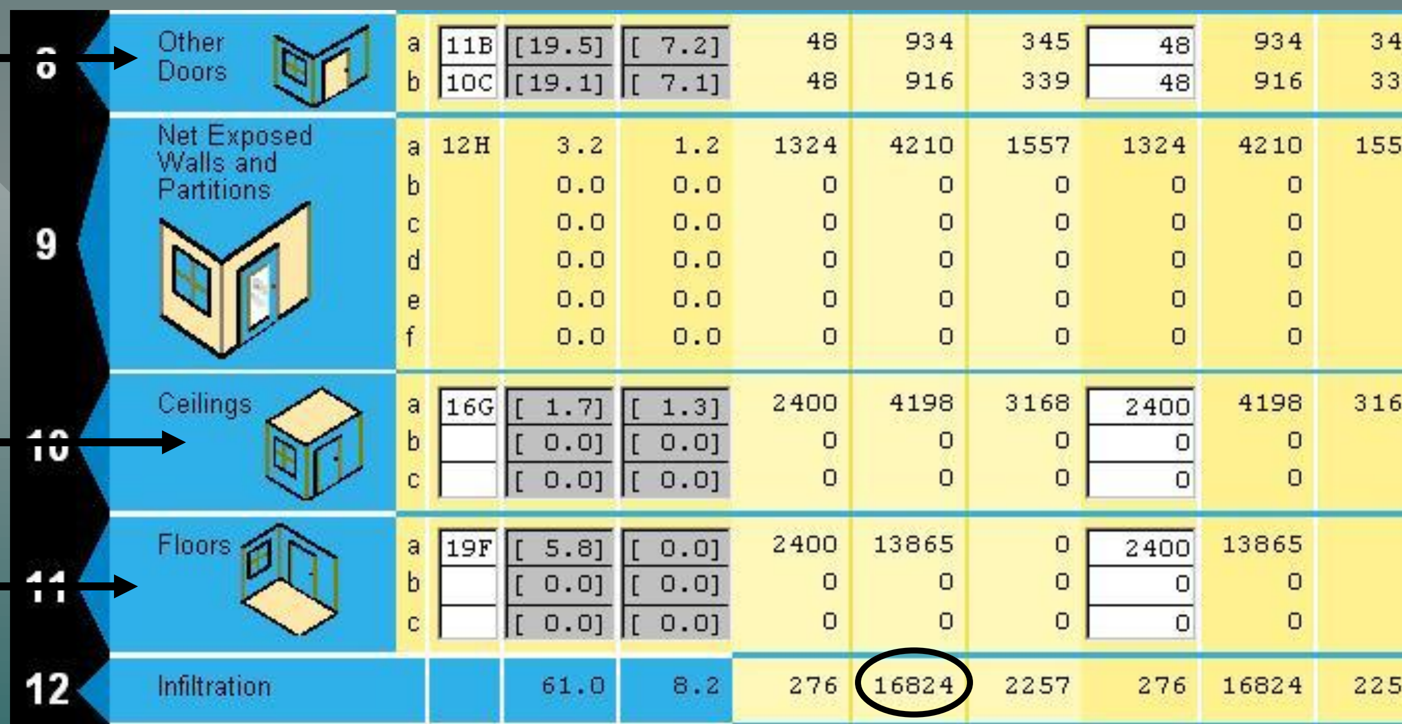
Doors, Ceiling, Floors & Infiltration

Input Doors

Input Ceilings

Input Floors

Infiltration



8	Other Doors	a	11B	[19.5]	[7.2]	48	934	345	48	934	34
		b	10C	[19.1]	[7.1]	48	916	339	48	916	33
9	Net Exposed Walls and Partitions	a	12H	3.2	1.2	1324	4210	1557	1324	4210	155
		b		0.0	0.0	0	0	0	0	0	
		c		0.0	0.0	0	0	0	0	0	
		d		0.0	0.0	0	0	0	0	0	
		e		0.0	0.0	0	0	0	0	0	
		f		0.0	0.0	0	0	0	0	0	
10	Ceilings	a	16G	[1.7]	[1.3]	2400	4198	3168	2400	4198	316
		b		[0.0]	[0.0]	0	0	0	0	0	
		c		[0.0]	[0.0]	0	0	0	0	0	
11	Floors	a	19F	[5.8]	[0.0]	2400	13865	0	2400	13865	
		b		[0.0]	[0.0]	0	0	0	0	0	
		c		[0.0]	[0.0]	0	0	0	0	0	
12	Infiltration			61.0	8.2	276	16824	2257	276	16824	225

Objectives: Building Loads
Residential

Loads Subtotals

HTG

Internal Gains

13	Subtotal Btuh Loss=6+8+9+10+11+12			47863			47863	
14	Duct Btuh Loss		10 %	4786		10 %	4786	
15	Total Btuh Loss = 13+14			52649			52649	
16	Internal Gains: People @	300	2		600	2		600
	Appliances @	1200	2		2400	2		2400
17	Subtotal RSH Gain=7+8+9+10+11+12+16				19022			19022
18	Duct Btuh Gain		5 %		951	5 %		951

CLG

CFM

15	Total Btuh Loss = 13+14		52649			52649	
19	Total RSH Gain = (17+18)*PLF	1.00		19973	1.00		19973
20	CFM air required		956	956		956	956

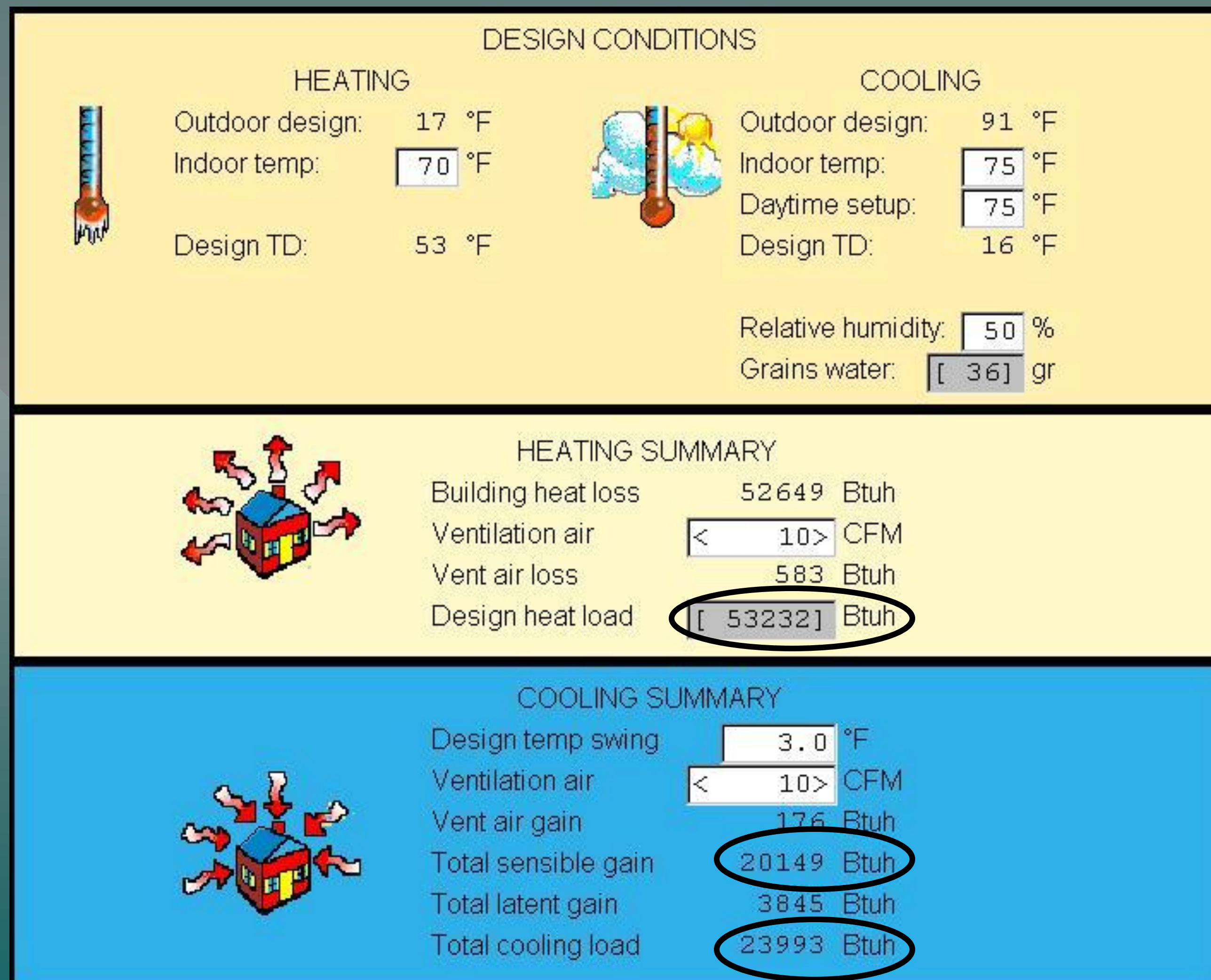
Objectives: Building Loads <u>Residential</u>

Heating and Cooling Loads Total

Design Conditions →

Heating Load →

Cooling Sensible Latent Total →



Objectives: Select Heat Pumps Residential

- Units are Normally Selected for Heating Load in Northern Climates
- Size Unit by the Dominate Load / Heating or Cooling
- Select 2 Stage High Efficiency Geothermal Units
- Unit Should Cover Approximately 95% of Annual Heating Requirements
- Must Check Sensible and Latent Cooling Capacity
- Use Manufacturers Software Program!!

Objectives: Select Heat Pumps

Residential

Packaged Units in

Upflow

Downflow

Horizontal

Split Units

Water to Water

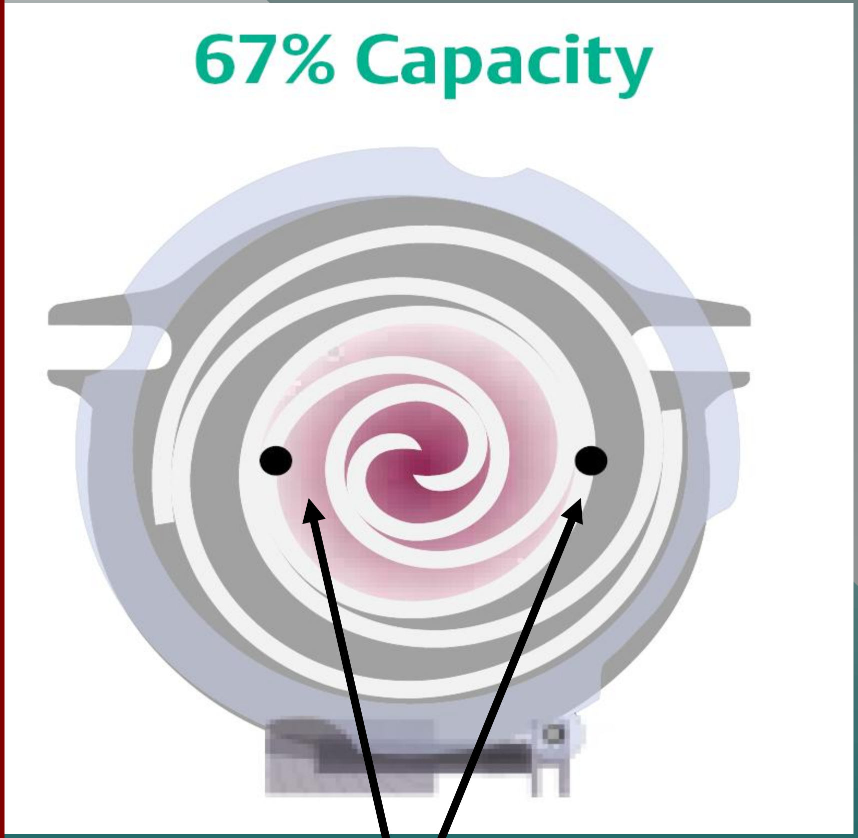
2-Stage Copeland UltraTech Compressor

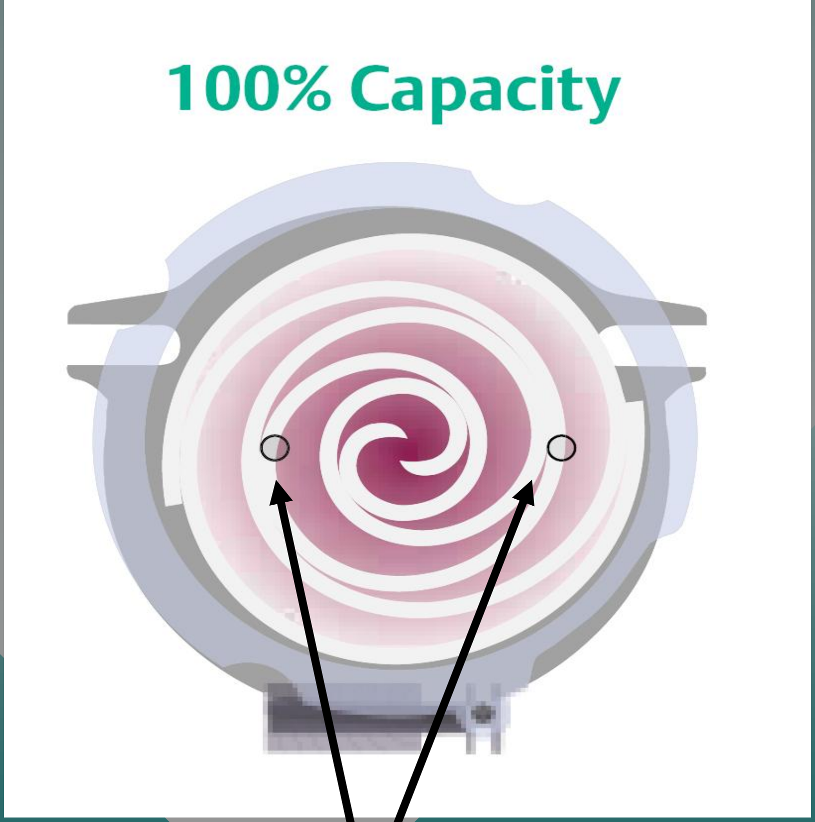
Solenoid Valve AC/DC converter "unloading" control

- Same "Footprint" as Single Speed Compressor
- Thicker Shell than R22 Version
- Anti-rotation Device to Insure Quiet Operation
- Solenoid Switches Speed
- R-410A Compressors Have Lower Failure Rates than R22

Copeland UltraTech /Two-Stage Unloading Scroll

With Copeland Scroll UltraTech™, two internal bypass ports enable the system to run at 67% part-load capacity for better efficiency and humidity control. Based on demand, the modulation ring is activated, sealing the bypass ports and instantly shifting capacity to 100%. Take advantage of "shift on the fly" stage changing (no stopping and starting required like other two-stage compressors).





Gas By-pass - Ports Open

Ports Closed

Objectives: Select Heat Pumps Commercial

- Unit Selected by Dominate Load / Typically Cooling in Commercial Applications
- Select Geothermal High Efficiency Units
- Unit Net Sensible Cooling Capacity Must Meet or Exceed Sensible Cooling Load - Verify Heating Capacity and Latent Capacity
- Dual Capacity Machines are Recommended
- Units Rated by ARI standard 13256-1
- “Reheat” option for humidity control

Objectives: Select Heat Pumps

ARI/ISO 13256-1 GLHP Ratings are at <u>77*F EWT for Cooling</u> and <u>32*F EWT for Heating</u>

ARI/ASHRAE/ISO 13256-1
English (IP) Units

Model	Capacity Modulation	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
		Cooling Water 86°F		Heating Water 68°F		Cooling Water 59°F		Heating Water 50°F		Cooling Full Load 77°F Part Load 68°F		Heating Full Load 32°F Part Load 41°F	
		Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP
TT026	Full	25,300	15.9	30,800	5.3	28,900	24.5	25,700	4.8	26,600	18.5	19,800	4.0
	Part	19,400	18.3	22,400	6.1	22,200	30.8	18,600	5.1	21,200	26.0	16,500	4.6
TT038	Full	36,200	15.6	44,800	5.3	41,200	23.0	36,700	4.7	38,200	18.2	29,000	4.0
	Part	26,200	18.5	30,800	6.3	30,200	31.5	24,800	5.1	28,900	27.0	22,100	4.5
TT049	Full	48,400	15.7	59,900	5.2	54,600	22.5	48,300	4.7	50,600	17.9	37,500	4.0
	Part	36,100	18.0	44,300	6.2	40,700	28.7	35,400	5.1	39,600	24.9	31,200	4.6
TT064	Full	61,500	15.0	72,300	5.0	68,600	22.0	59,600	4.4	64,800	17.5	48,000	3.9
	Part	44,900	17.6	51,100	5.7	51,900	29.7	41,800	4.7	49,800	25.3	37,500	4.3

Cooling capacities based upon 80.6°F DB, 66.2°F WB entering air temperature
Heating capacities based upon 68°F DB, 59°F WB entering air temperature
All ratings based upon 208V operation
Ground loop heat pump ratings based upon 15% antifreeze solution

Certified in accordance with the ARI/ISO Standard 13256-1 Certification Program, which replaced ARI Standard-320, 325, and 330.

Rev: 07/06/04

Objectives: Select Heat Pumps Commercial

Commercial applications may require larger capacity products, rooftop units, console products or vertical stack products.

Objectives: Select Heat Pumps Residential

Units are Rated at AHRI Conditions

Units Need to be Selected at **Maximum and Minimum** Loop Design Temperatures

Typically 30*F Minimum Entering Water Temperature (EWT) & 95*F Maximum EWT

Objectives: Select Heat Pumps

Check Spec Catalog Data at Design EWT

3 Ton Heating Example

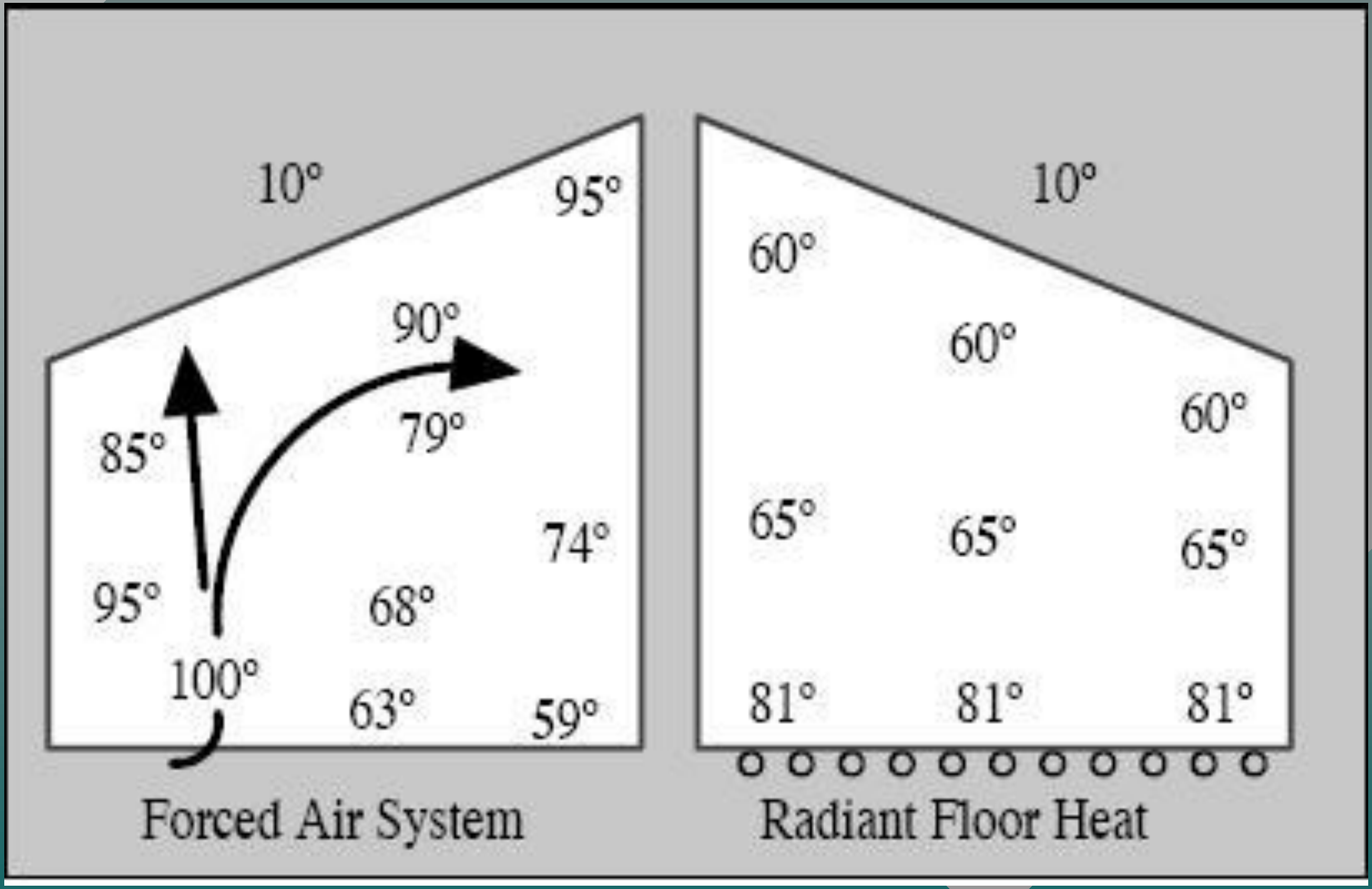
EWT °F	GPM	WPD PSI	WPD FT	Cooling - EAT 80/67°F Airflow CFM	TC	SC	kW	HR	EER	HWC	Heating - EAT 70°F Airflow CFM	HC	kW	HE	LAT	COP	HWC
20	9.0	5.9	13.7	Operation not recommended							1080	25.7	2.28	18.2	92.0	3.30	2.9
	9.0	5.9	13.7								1250	26.2	2.18	18.8	89.4	3.51	2.5
30	4.5	1.7	3.9	1080	43.1	27.4	1.55	48.3	27.9	-	1080	27.9	2.32	20.2	93.9	3.52	3.0
	4.5	1.7	3.9	1250	44.1	30.1	1.61	49.6	27.3	-	1250	28.4	2.22	20.9	91.1	3.75	2.6
	6.8	3.3	7.7	1080	43.3	27.5	1.44	48.1	30.0	-	1080	29.2	2.35	21.4	95.0	3.64	3.0
	6.8	3.3	7.7	1250	44.3	30.1	1.51	49.4	29.4	-	1250	29.7	2.25	22.1	92.0	3.87	2.6
	9.0	5.7	13.1	1080	43.4	27.5	1.39	48.1	31.2	-	1080	29.9	2.36	22.0	95.6	3.71	2.9
	9.0	5.7	13.1	1250	44.4	30.1	1.45	49.4	30.6	-	1250	30.4	2.26	22.8	92.5	3.94	2.5

3 Ton Cooling Example

85	4.5	1.0	2.2	1080	34.8	24.3	2.57	43.6	13.6	3.7	1080	50.5	2.92	40.6	113.3	5.08	4.4
	4.5	1.0	2.2	1250	35.6	26.7	2.68	44.8	13.3	3.8	1250	51.5	2.80	41.9	108.1	5.40	3.8
	6.8	2.8	6.4	1080	36.2	25.0	2.40	44.4	15.0	3.2	1080	53.5	3.02	43.2	115.9	5.20	4.4
	6.8	2.8	6.4	1250	37.0	27.4	2.51	45.6	14.7	3.2	1250	54.5	2.89	44.7	110.4	5.53	3.8
	9.0	4.5	10.3	1080	36.8	25.3	2.33	44.8	15.8	2.6	1080	55.2	3.07	44.7	117.3	5.26	4.3
	9.0	4.5	10.3	1250	37.7	27.7	2.43	46.0	15.5	2.7	1250	56.3	2.95	46.2	111.7	5.59	3.7
90	4.5	0.9	2.1	1080	33.8	23.9	2.70	43.0	12.5	4.1	1080	52.7	2.99	42.5	115.2	5.17	4.6
	4.5	0.9	2.1	1250	34.6	26.2	2.81	44.2	12.3	4.2	1250	53.7	2.86	44.0	109.8	5.50	4.0
	6.8	2.7	6.2	1080	35.1	24.5	2.52	43.8	13.9	3.5	1080	55.9	3.10	45.3	117.9	5.29	4.6
	6.8	2.7	6.2	1250	36.0	26.9	2.63	45.0	13.7	3.6	1250	57.0	2.97	46.9	112.2	5.62	4.0
	9.0	4.4	10.2	1080	35.8	24.8	2.44	44.2	14.7	2.9	1080	57.7	3.16	46.9	119.5	5.35	4.5
	9.0	4.4	10.2	1250	36.7	27.2	2.55	45.4	14.4	3.0	1250	58.8	3.03	48.5	113.6	5.69	3.9
100	4.5	0.8	1.9	1080	31.8	22.9	2.99	42.0	10.6	5.0							
	4.5	0.8	1.9	1250	32.5	25.2	3.12	43.2	10.4	5.1							
	6.8	2.6	6.1	1080	33.1	23.5	2.80	42.6	11.8	4.3							
	6.8	2.6	6.1	1250	33.8	25.8	2.92	43.8	11.6	4.3							
	9.0	4.2	9.7	1080	33.7	23.9	2.70	43.0	12.5	3.5							
	9.0	4.2	9.7	1250	34.5	26.2	2.82	44.2	12.2	3.6							

Objectives: Select Heat Pumps Residential Water to Water

Radiant Floor Heating
Comfort Levels

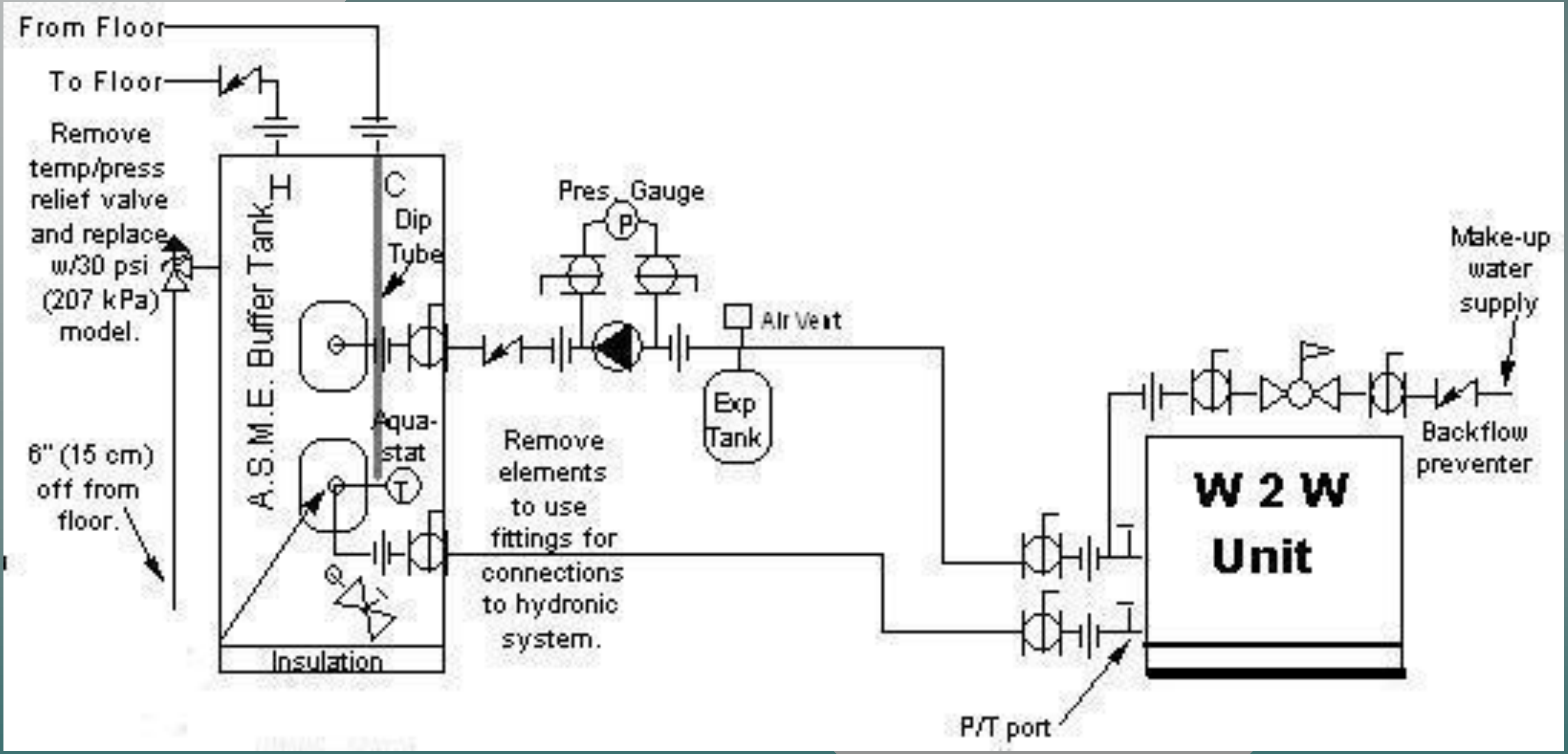


Objectives: Select Heat Pumps Residential Water to Water

Radiant
Floor
Install

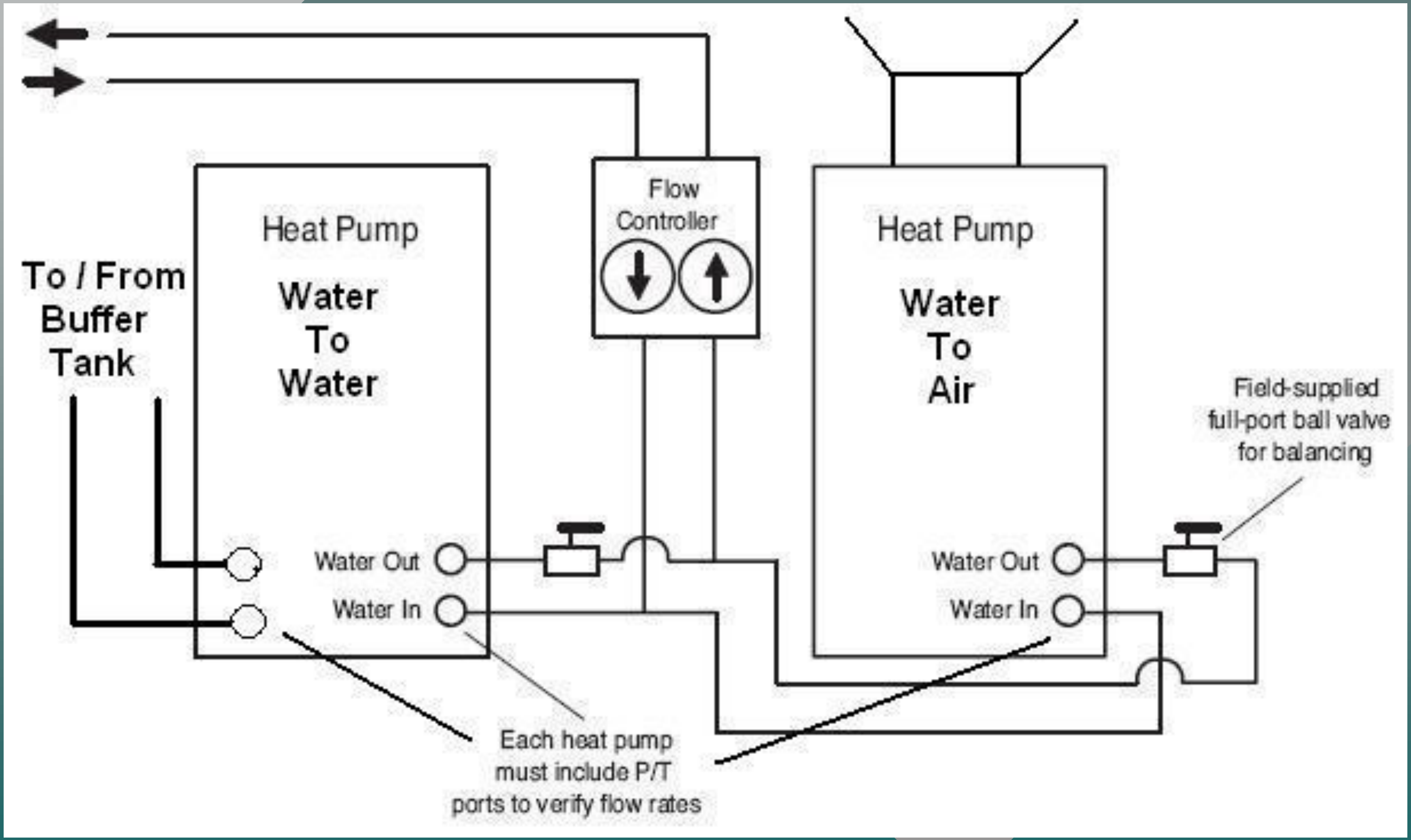
Objectives: Water to Water

Typical Installation



Objectives: Water to Water

W to W with W to A Units



Objectives: Select Heat Pumps Residential Water to Water

Equipment Rated at GLHP or GWHP

Load / Heated Water at 86*F EWT & 104*F

Source at 32*F EWT or 50*F EWT

60Hz Units	Ground Loop Heat Pump				Ground Water Heat Pump			
Model	Heating				Heating			
	Indoor 86/95°F, Outdoor 32/27°F*		Indoor 104/113°F, Outdoor 32/27°F*		Indoor 86/95°F, Outdoor 50/45°F*		Indoor 104/113°F, Outdoor 50/45°F*	
	Indoor 30/35°C, Outdoor 0/-3°C*		Indoor 40/45°C, Outdoor 0/-3°C*		Indoor 30/35°C, Outdoor 10/7°C*		Indoor 40/45°C, Outdoor 10/7°C*	
	Capacity	COP	Capacity	COP	Capacity	COP	Capacity	COP
	Btuh [kW]	W/W	Btuh [kW]	W/W	Btuh [kW]	W/W	Btuh [kW]	W/W
THW010	32.6 [9.57]	4.2	30.8 [9.03]	3.3	42.6 [12.50]	5.2	39.9 [11.69]	4.1

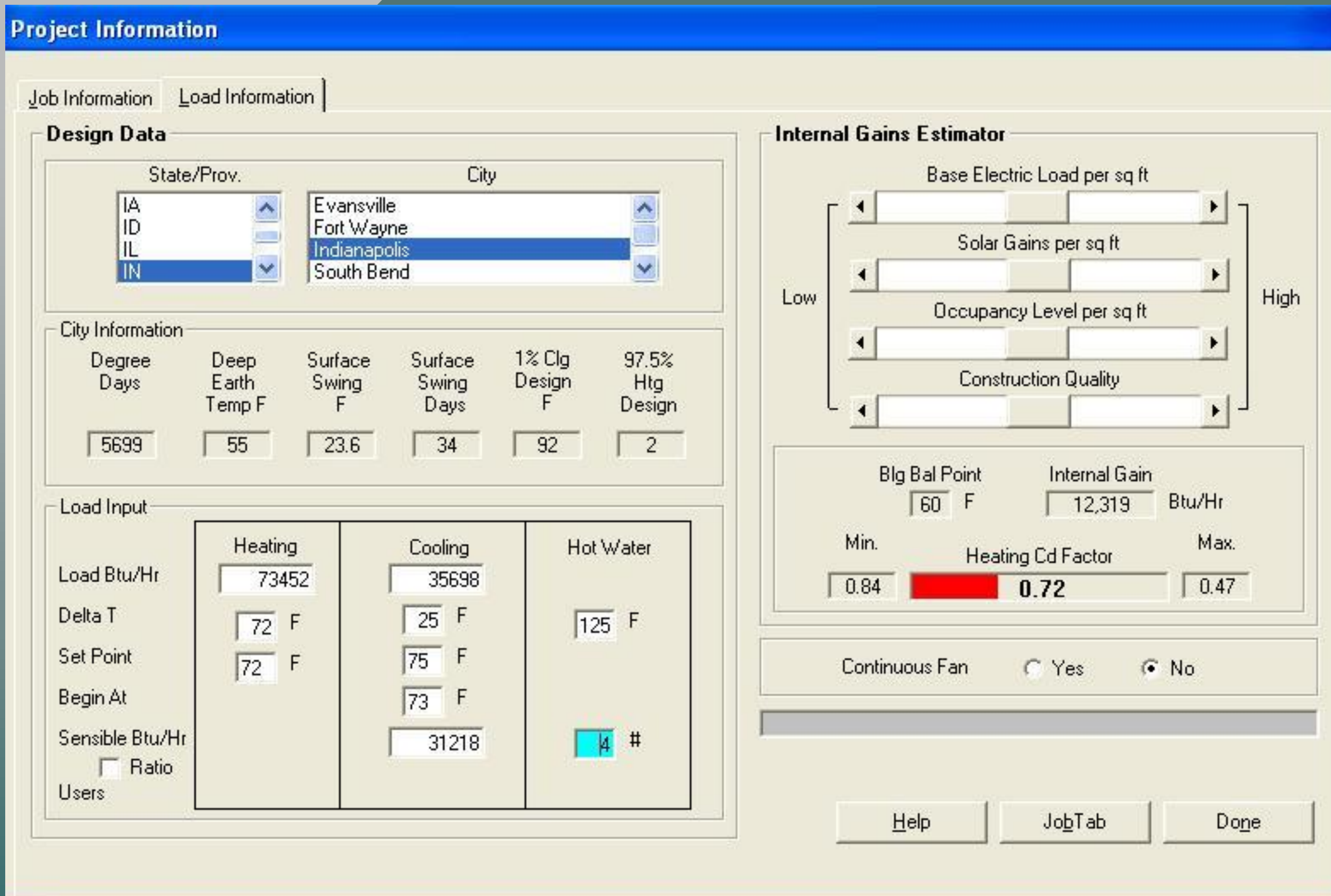
Objectives: Water to Water / 3 Ton

Select Unit by Capacity at System Peak Conditions
30*F EWT Source & 3 GPM / Ton and
Leaving Load Temperature & 3 GPM / Ton

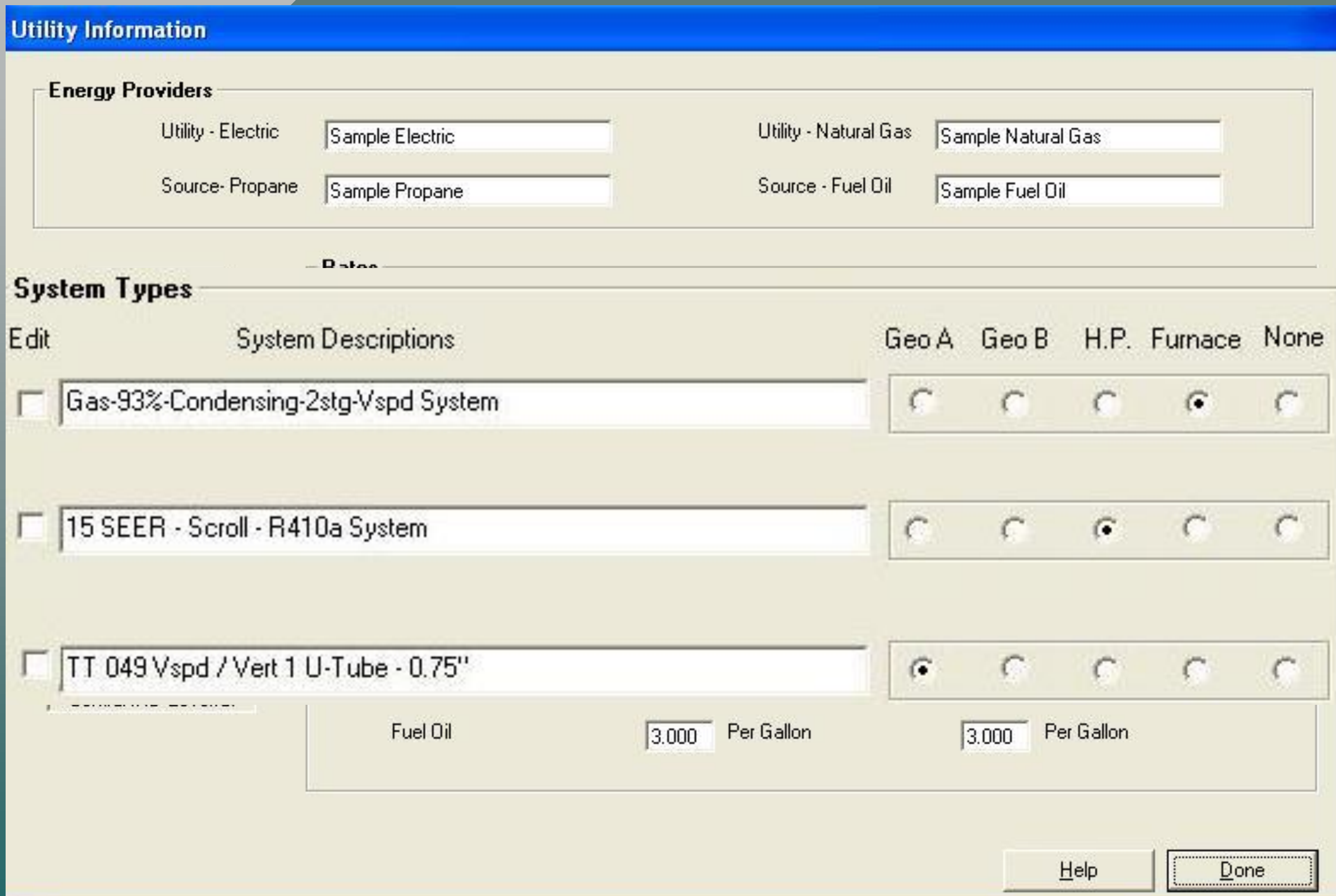
SOURCE				LOAD																					
EWT	Flow			EWT	Flow 4.5 GPM							Flow 6.8 GPM							Flow 9.0 GPM						
	GPM	WPD			HC	Power	HE	LWT	COP	WPD		HC	Power	HE	LWT	COP	WPD		HC	Power	HE	LWT	COP	WPD	
F		PSI	FT		Mbtuh	KW	Mbtuh	F		PSI	FT	Mbtuh	KW	Mbtuh	F		PSI	FT	Mbtuh	KW	Mbtuh	F		PSI	FT
20	9.0	7.7	17.9	60	26.1	1.53	20.9	71.6	5.0	0.5	1.2	26.4	1.45	21.5	67.8	5.3	1.3	3.1	26.5	1.41	21.7	65.9	5.5	2.5	5.8
				80	25.7	1.96	19.0	91.4	3.8	0.4	0.9	25.9	1.86	19.6	87.7	4.1	1.2	2.8	25.9	1.81	19.8	85.8	4.2	2.3	5.4
				100	25.0	2.56	16.3	111.1	2.9	0.3	0.7	25.0	2.42	16.7	107.4	3.0	1.1	2.5	24.9	2.36	16.9	105.5	3.1	2.1	4.9
30	4.5	1.7	4.0	60	27.1	1.54	21.9	72.1	5.2	0.5	1.2	27.5	1.45	22.5	68.1	5.5	1.3	3.1	27.6	1.42	22.7	66.1	5.7	2.5	5.8
				80	26.7	1.97	20.0	91.9	4.0	0.4	0.9	27.0	1.86	20.6	88.0	4.2	1.2	2.8	27.0	1.81	20.8	86.0	4.4	2.3	5.4
				100	26.1	2.56	17.3	111.6	3.0	0.3	0.7	26.1	2.43	17.8	107.7	3.2	1.1	2.5	26.0	2.36	18.0	105.8	3.2	2.1	4.9
				120	25.1	3.32	13.8	131.2	2.2	0.2	0.5	24.9	3.14	14.2	127.4	2.3	0.9	2.1	24.7	3.06	14.3	125.5	2.4	1.8	4.3
	6.8	4.1	9.4	60	28.4	1.54	23.2	72.6	5.4	0.5	1.2	28.8	1.46	23.8	68.5	5.8	1.3	3.1	28.9	1.42	24.1	66.4	6.0	2.5	5.8
				80	27.9	1.97	21.2	92.4	4.2	0.4	0.9	28.2	1.87	21.8	88.4	4.4	1.2	2.8	28.2	1.82	22.0	86.3	4.6	2.3	5.4
				100	27.1	2.57	18.3	112.0	3.1	0.3	0.7	27.2	2.43	18.9	108.0	3.3	1.1	2.5	27.1	2.37	19.0	106.0	3.4	2.1	4.9
				120	25.9	3.33	14.6	131.5	2.3	0.2	0.5	25.7	3.15	15.0	127.6	2.4	0.9	2.1	25.6	3.07	15.1	125.7	2.4	1.8	4.3
	9.0	7.1	16.4	60	29.2	1.54	23.9	73.0	5.5	0.5	1.2	29.6	1.46	24.6	68.8	5.9	1.3	3.1	29.7	1.42	24.8	66.6	6.1	2.5	5.8
				80	28.6	1.98	21.9	92.7	4.2	0.4	0.9	28.9	1.87	22.5	88.6	4.5	1.2	2.8	28.9	1.82	22.7	86.4	4.7	2.3	5.4
				100	27.7	2.58	18.9	112.3	3.2	0.3	0.7	27.8	2.44	19.5	108.2	3.3	1.1	2.5	27.7	2.37	19.6	106.2	3.4	2.1	4.9
				120	26.4	3.34	15.0	131.7	2.3	0.2	0.5	26.2	3.16	15.4	127.8	2.4	0.9	2.1	26.1	3.08	15.6	125.8	2.5	1.8	4.3
40	4.5	1.5	3.5	60	30.0	1.55	24.7	93.3	5.7	0.4	0.9	30.4	1.46	25.4	89.0	6.1	1.2	2.8	30.5	1.42	25.7	86.8	6.3	2.3	5.4
				80	29.0	2.26	21.3	112.9	3.8	0.3	0.7	29.2	2.14	21.9	108.7	4.0	1.1	2.5	29.3	2.08	22.2	106.5	4.1	2.1	4.9
				100	28.6	2.58	19.8	132.7	3.2	0.2	0.5	28.7	2.44	20.3	128.5	3.4	0.9	2.1	28.6	2.38	20.5	126.4	3.5	1.8	4.3
				120	31.4	1.55	26.1	74.0	5.9	0.5	1.2	31.9	1.47	26.9	69.5	6.4	1.3	3.1	32.0	1.43	27.2	67.1	6.6	2.5	5.8
	6.8	3.7	8.6	60	30.8	1.99	24.0	93.7	4.5	0.4	0.9	31.1	1.88	24.7	89.2	4.8	1.2	2.8	31.2	1.83	24.9	86.9	5.0	2.3	5.4
				80	29.7	2.59	20.9	113.2	3.4	0.3	0.7	29.9	2.45	21.5	108.9	3.6	1.1	2.5	29.8	2.38	21.7	106.6	3.7	2.1	4.9
				100	28.3	3.35	16.9	132.6	2.5	0.2	0.5	28.2	3.17	17.4	128.4	2.6	0.9	2.1	28.1	3.09	17.6	126.2	2.7	1.8	4.3
				120	32.2	1.55	26.9	74.3	6.1	0.5	1.2	32.7	1.47	27.7	69.7	6.5	1.3	3.1	32.9	1.43	28.0	67.3	6.7	2.5	5.8
	9.0	6.5	15.1	60	31.5	1.99	24.7	94.0	4.6	0.4	0.9	31.9	1.89	25.4	89.4	5.0	1.2	2.8	31.9	1.84	25.7	87.1	5.1	2.3	5.4
				80	30.4	2.59	21.5	113.5	3.4	0.3	0.7	30.5	2.45	22.2	109.0	3.6	1.1	2.5	30.5	2.39	22.4	106.8	3.7	2.1	4.9
				100	28.9	3.36	17.4	132.8	2.5	0.2	0.5	28.8	3.18	17.9	128.5	2.7	0.9	2.1	28.7	3.09	18.1	126.4	2.7	1.8	4.3
				120	28.9	3.36	17.4	127.7	2.5	0.2	0.5	28.8	3.18	17.9	125.3	2.7	0.9	2.1	28.7	3.09	18.1	124.0	2.7	1.8	4.3

•Objectives: GeoDesigner for System Design

•Objectives: Job Info / Load Info



•Objectives: Main Screen, Utilities and Select System Types



Objectives: Select Heat Pumps Software

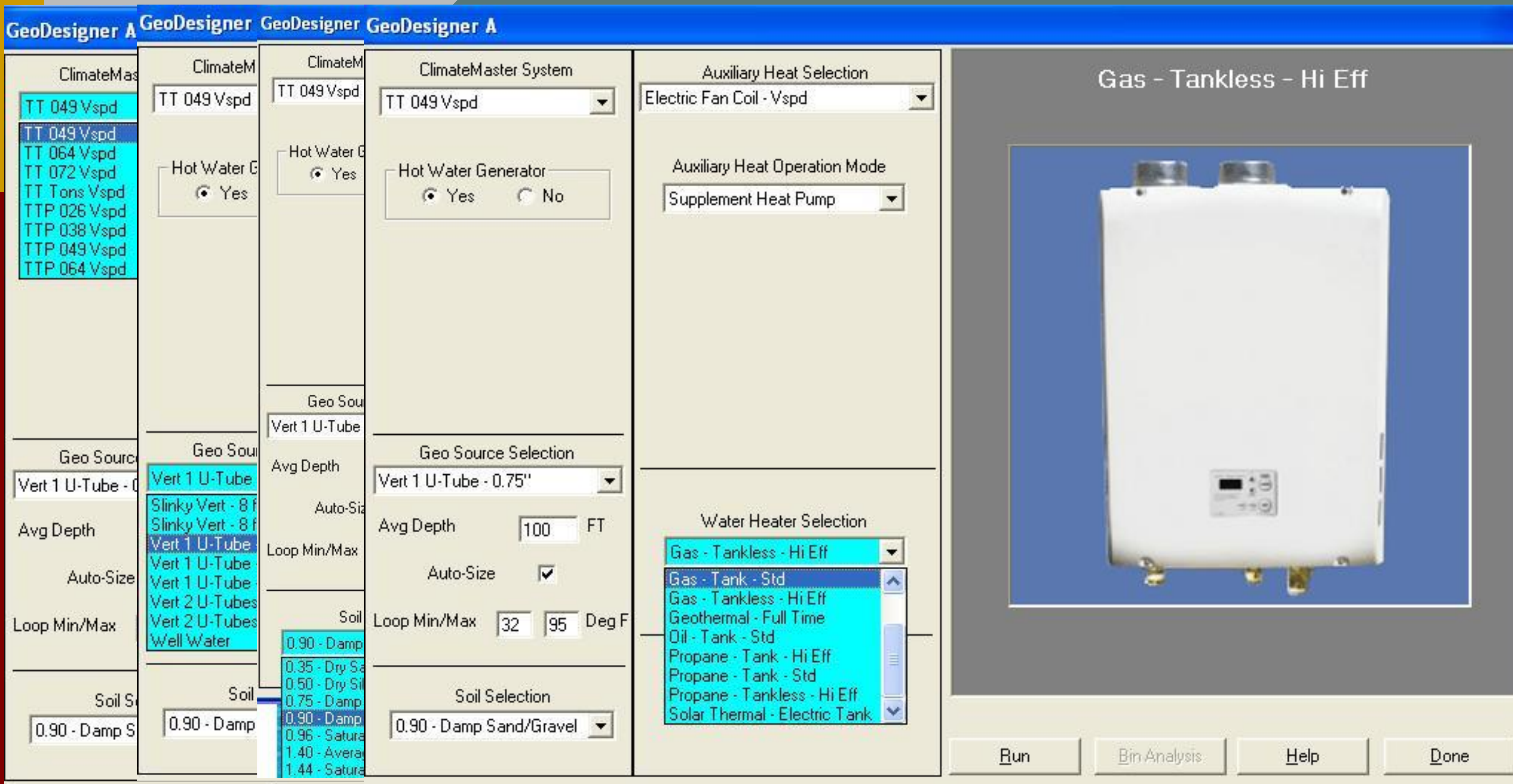
Building Design Loads / Example

Notes:	Any HAVC Customer		Notes:	Any MN GSHP Asoc Dealer	

Design Data

Heating Load:	84,629	Btu/Hr	Heating Setpoint:	72	Deg F
Htg Load Temp Diff:	85	Deg F	Cooling Setpoint:	75	Deg F
Cooling Load:	31,289	Btu/Hr	Begin Cooling At:	73	Deg F
Clg Load Temp Diff:	20	Deg F	Hot Water Setpoint:	130	Deg F
Sensible Cooling:	27,826	Btu/Hr	Hot Water Users:	4	
			Continuous Fan:	No	
Reference City:	Minneapolis, MN				
Winter Design:	-12	Deg F	Annual Heating:	169.1	Million Btu
Summer Design:	92	Deg F	Annual Cooling:	14.4	Million Btu
Bldg Balance Temp:	61	Deg F	Annual Water Heating:	22.1	Million Btu
Avg Internal Gains:	11,067	Btu/Hr	Daily Hot Water Use:	70	Gallons

•Objectives: Select Geo Unit, Loop Type and H2O Heating Method

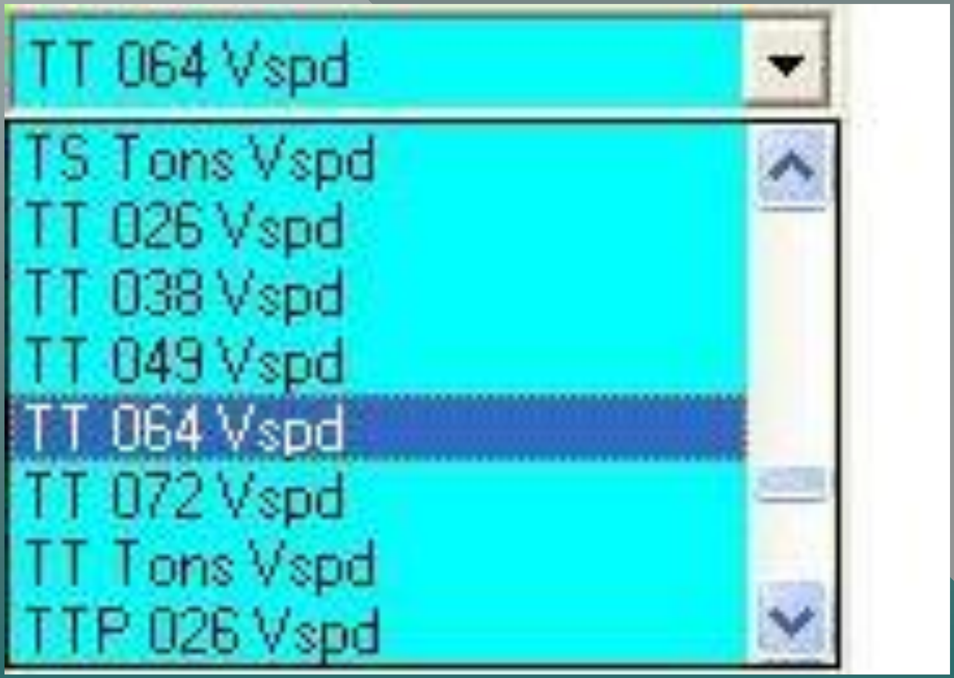


Objectives: Select Heat Pumps

Software Program

Select Unit Via Drop Down Menu

Packaged, Split or W 2 W Units



Objectives: Select Heat Pumps Software

Percentage of Annual Heating Load / 4 Ton

TT 049 Vspd / Vert 1 U-Tube - 0.75"

Geothermal Source			Heating		
Bore Length:	1,010	Feet	Geothermal	3.59	COP
				85	% of Htg
Max Cooling:	68	Deg F		$874	Annual
Avg Cooling:	56	Deg F			
Avg Heating:	33	Deg F	Aux Heating	100	% Eff
Min Heating:	30	Deg F		15	% of Htg
				$575	Annual
Deep Earth Temp:	47	Deg F			
Soil Conductivty:	0.90		Tot Heating	$1,449	Annual
Soil Diffusivity:	0.64				

Objectives: Select Heat Pumps Software

Percentage of Annual Heating Load / 5 Ton

TT 064 Vspd / Vert 1 U-Tube - 0.75"

Geothermal Source			Heating		
Bore Length:	1,280	Feet	Geothermal	3.56	COP
				93	% of Htg
Max Cooling:	63	Deg F		$972	Annual
Avg Cooling:	53	Deg F			
Avg Heating:	35	Deg F	Aux Heating	100	% Eff
Min Heating:	30	Deg F		7	% of Htg
				$254	Annual
Deep Earth Temp:	47	Deg F			
Soil Conductivty:	0.90		Tot Heating	$1,226	Annual
Soil Diffusivity:	0.64				

Objectives: Select Heat Pumps Software

Percentage of Annual Heating Load / 6 Ton

TT 072 Vspd / Vert 1 U-Tube - 0.75"

Geothermal Source		
Bore Length:	1,315	Feet
Max Cooling:	62	Deg F
Avg Cooling:	53	Deg F
Avg Heating:	36	Deg F
Min Heating:	30	Deg F
Deep Earth Temp:	47	Deg F
Soil Conductivty:	0.90	
Soil Diffusivity:	0.64	

Heating		
Geothermal	3.00	COP
	96	% of Htg
	$1,185	Annual
Aux Heating	100	% Eff
	4	% of Htg
	$165	Annual
Tot Heating	$1,350	Annual

Objectives: Select Heat Pumps Software

Operating Cost / 4 Ton Versus 5 Ton

Estimated Operating Cost Summary

System	Heating Cost	Cooling Cost	Hot Water Cost	Constant Fan	Total Cost	Per Month
TT 049 Vspd / Vert 1 U-Tube - 0.75"	$1,449	$31	$305	$0	$1,786	$149
TT 064 Vspd / Vert 1 U-Tube - 0.75"	$1,226	$29	$319	$0	$1,574	$131
No Option Selected	$0	$0	$0	$0	$0	$0

Comments:
Sizing a GSHP System

1122012
MN Sizing GSHP 2012.ged

Utility Cost	Rate	Summer	Winter
Electric - Geothermal	$/kwh	.075	.075
Electric - Heat Pump	$/kwh	.075	.075
Electric - Furnace	$/kwh	.075	.075
Natural Gas	$/therm	1.00	1.00
Propane	$/gallon	2.25	2.25
Fuel Oil	$/gallon	3.00	3.00

Objectives: Select Heat Pumps Software

Operating Cost / 5 Ton Versus 6 Ton

Estimated Operating Cost Summary

System	Heating Cost	Cooling Cost	Hot Water Cost	Constant Fan	Total Cost	Per Month
TT 064 Vspd / Vert 1 U-Tube - 0.75"	$1,226	$29	$319	$0	$1,574	$131
TT 072 Vspd / Vert 1 U-Tube - 0.75"	$1,350	$34	$327	$0	$1,710	$143
No Option Selected	$0	$0	$0	$0	$0	$0

Objectives: Select Heat Pumps Software

Operating Cost 5 Ton Geo VS Gas AC & ASHP

Estimated Operating Cost Summary

System	Heating Cost	Cooling Cost	Hot Water Cost	Constant Fan	Total Cost	Per Month
Gas-93%-Condensing-2stg-Vspd System	$1,972	$105	$381	$0	$2,458	$205
14 SEER - Scroll - R410a System	$2,219	$110	$551	$0	$2,881	$240
TT 064 Vspd / Vert 1 U-Tube - 0.75"	$1,226	$29	$319	$0	$1,574	$131

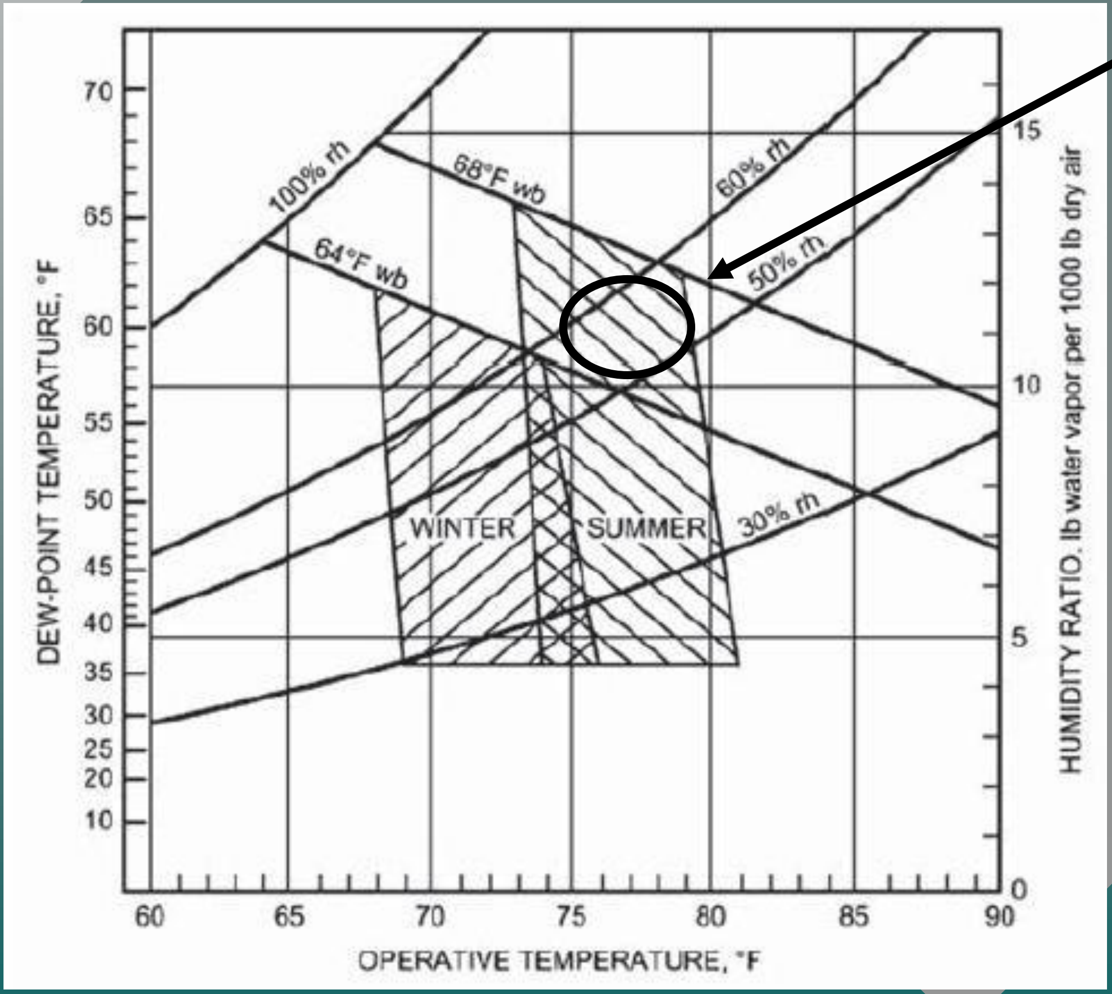
Comments:
Sizing a GSHP System

1122012
MN Sizing GSHP 2012.ged

Utility Cost	Rate	Summer	Winter
Electric - Geothermal	$/kwh	.075	.075
Electric - Heat Pump	$/kwh	.075	.075
Electric - Furnace	$/kwh	.075	.075
Natural Gas	$/therm	1.00	1.00
Propane	$/gallon	2.25	2.25
Fuel Oil	$/gallon	3.00	3.00

Objectives: Select Heat Pumps Latent Capacity

Typical Indoor Humidity Levels Maintained at 50/55% RH



Objectives: Select Heat Pumps Latent Load

Determine Latent Cooling Load

Notes: Any HAVC Customer — Notes: Any MN GSHP Asoc Dealer

Design Data

Heating Load:	84,629	Btu/Hr	Heating Setpoint:	72	Deg F
Htg Load Temp Diff:	85	Deg F	Cooling Setpoint:	75	Deg F
Cooling Load:	31,289	Btu/Hr	Begin Cooling At:	73	Deg F
Clg Load Temp Diff:	20	Deg F	Hot Water Setpoint:	130	Deg F
Sensible Cooling:	27,826	Btu/Hr	Hot Water Users:	4	
			Continuous Fan:	No	
Reference City:	Minneapolis, MN				
Winter Design:	-12	Deg F	Annual Heating:	169.1	Million Btu
Summer Design:	92	Deg F	Annual Cooling:	14.4	Million Btu
Bldg Balance Temp:	61	Deg F	Annual Water Heating:	22.1	Million Btu
Avg Internal Gains:	11,067	Btu/Hr	Daily Hot Water Use:	70	Gallons

Latent Load = Total Minus Sensible

31,289 – 27,826=

3,463 Latent

Objectives: Select Heat Pumps

Check Spec Catalog Data at Design EWT

EWT °F	GPM	WPD		COOLING - EAT 80/67 °F							HEATING - EAT 70°F						
		PSI	FT	Airflow CFM	TC	SC	kW	HR	EER	HWC	Airflow CFM	HC	kW	HE	LAT	COP	HWC
20	7.5	0.8	1.9	1580	Operation not recommended						Operation not recommended						
				1825													
	11.3	2.4	5.5	1580													
				1825													
	15.0	5.0	11.6	1580							1750	41.0	3.86	27.8	91.7	3.12	4.0
				1825							2050	41.8	3.71	29.1	88.9	3.30	3.5
30	7.5	0.6	1.5	1580	66.0	42.1	2.79	75.5	23.7	-	1750	44.6	3.87	31.4	93.6	3.38	4.1
				1825	67.3	45.6	2.90	77.2	23.2	-	2050	45.4	3.73	32.7	90.5	3.57	3.6
	11.3	2.3	5.3	1580	67.0	42.6	2.67	76.1	25.1	-	1750	46.4	3.92	33.0	94.6	3.47	4.1
				1825	68.3	46.2	2.77	77.8	24.7	-	2050	47.3	3.77	34.4	91.4	3.67	3.5
	15.0	4.8	11.0	1580	68.4	43.5	2.61	77.3	26.2	-	1750	47.4	3.95	34.0	95.1	3.52	4.0
				1825	69.7	47.1	2.71	78.9	25.7	-	2050	48.3	3.80	35.4	91.8	3.73	3.5

Cooling 5 Ton at 1825 CFM

EWT °F	GPM	PSI	FT	Airflow CFM	TC	SC	kW	HR	EER	HWC	Airflow CFM	HC	kW	HE	LAT	COP	HWC
60	7.5	0.3	0.8	1580	66.0	43.9	3.58	78.2	18.5	2.9	1750	63.0	4.47	47.8	103.3	4.14	4.8
				1825	67.3	47.6	3.72	80.0	18.1	3.0	2050	64.2	4.29	49.5	99.0	4.38	4.2
	11.3	2.1	4.7	1580	67.5	44.3	3.36	78.9	20.1	2.5	1750	66.0	4.55	50.5	104.9	4.25	4.7
				1825	68.8	48.0	3.50	80.7	19.7	2.5	2050	67.2	4.38	[illegible]	[illegible]	4.50	4.1
	15.0	4.1	9.4	1580	68.0	44.4	3.26	79.2	20.9	2.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.31	4.7
				1825	69.4	48.1	3.39	80.9	20.5	2.1	2050	68.9	4.43	53.8	101.1	4.57	4.0
70	7.5	0.3	0.7	1580	63.3	43.1	3.92	76.7	16.1	4.0	1750	69.5	4.66	53.6	106.8	4.38	5.3
				1825	64.6	46.7	4.08	78.5	15.8	4.0	[illegible]	[illegible]	4.48	[illegible]	[illegible]	[illegible]	4.6
	11.3	2.0	4.5	1580	65.3	43.7	3.68	77.8	17.7	3.4	1750	73.0	4.76	56.7	108.6	4.49	5.2
				1825	66.5	47.3	3.82	79.6	17.4	3.4	2050	74.3	4.58	58.7	103.6	4.76	4.5
	15.0	3.9	8.9	1580	66.2	44.0	3.56	78.3	18.6	2.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.56	5.1
				1825	67.5	47.6	3.70	80.1	18.2	2.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.83	4.4
80	7.5	0.2	0.5	1580	60.0	41.9	4.33	74.8	13.9	5.2	1750	76.2	4.86	59.6	110.3	4.60	5.8
				1825	61.2	45.4	4.50	76.6	13.6	5.3	2050	77.6	4.67	61.7	105.1	4.87	5.1
	11.3	1.9	4.4	1580	62.3	42.7	4.05	76.1	15.4	4.4	[illegible]	[illegible]	[illegible]	63.2	112.5	4.72	5.7
				1825	63.5	46.3	4.21	77.9	15.1	4.5	[illegible]	[illegible]	[illegible]	65.4	106.9	5.00	5.0
	15.0	3.6	8.4	1580	63.4	43.1	3.91	76.8	16.2	3.6	1750	82.6	5.05	65.3	113.7	4.79	5.6

Latent = TC – SC

69,440 – 48,100 =

11,340 LATENT CAPACITY

Objectives: Select Heat Pumps Software

Cooling Run Time for Dehumidification

Temperature Bin Analysis

TT 064 Vspd / Vert 1 U-Tube - 0.75"

Outdoor Air Temp	Annual Weather Hours	Space Load Btu/Hr	Hot Water Load Btu/Hr	Geo Source Temp	Htg - Clg Capacity Btu/Hr	H.W. Gen Capacity Btu/Hr	Geo Run Time	Geo Operating Cost	Aux Heating Cost	Aux Hot Water Cost
112										
107										
102										
97	1	33,311	2,521	63	50,499	2,880	66%	$0.12		$0.02
92	32	28,256	2,521	60	51,238	2,583	55%	$3.22		$0.88
87	127	23,200	2,521	57	51,976	2,286	45%	$9.99		$4.76
82	267	18,145	2,521	53	52,712	1,990	34%	$15.64		$12.24
77	430	13,089	2,521	50	53,446	1,695	24%			$22.61
72	617		2,521							$38.84

50% Run Time?

Dehumidification Feature

Unit Sized for Full Heating/Oversized Cooling

Dehumidification Mode settings: The dehumidification mode setting provides field selection of humidity control. When operating in the normal mode, the cooling airflow settings are determined by the cooling tap setting above. When dehumidification is enabled there is a reduction in airflow in cooling to increase the moisture removal of the heat pump. Consult submittal data or specifications catalog for the specific unit series and model to correlate speed tap to airflow in CFM. The dehumidification mode can be enabled in two ways.

Constant Dehumidification Mode: When the dehumidification mode is selected (via DIP switch or jumper setting), the ECM motor will operate with a multiplier applied to the cooling CFM settings (approx. 20-25% lower airflow). Any time the unit is running in the cooling mode, it will operate at the lower airflow to improve latent capacity. The "DEHUM" LED will be illuminated at all times. Heating airflow is not affected. NOTE: Do not select dehumidification mode if cooling

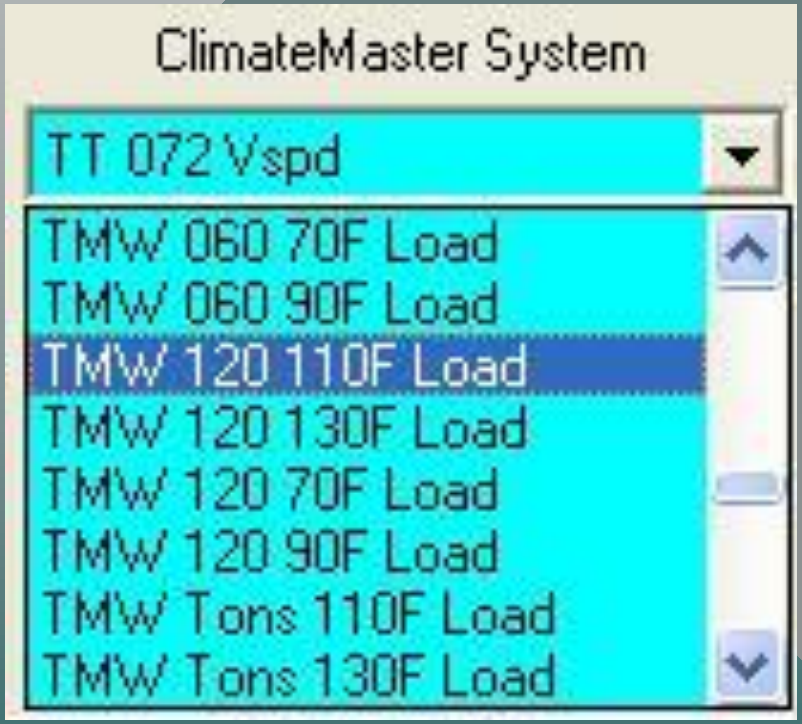
Dehumidification Feature

Unit Sized for Heating/Oversized Cooling

Model	Max ESP (in. wg)	Fan Motor (hp)	Tap Setting	Cooling Mode			Dehumid Mode			Heating Mode			AUX CFM	Aux/ Emerg Mode
				Stg 1	Stg 2	Fan	Stg 1	Stg 2	Fan	Stg 1	Stg 2	Fan		
026	0.50	1/2	4	810	950	475	630	740	475	920	1060	475	4	1060
	0.50	1/2	3	725	850	425	560	660	425	825	950	425	3	950
	0.50	1/2	2	620	730	370	490	570	370	710	820	370	2	820
	0.50	1/2	1	520	610	300				600	690	300	1	690
038	0.50	1/2	4	1120	1400	700	870	1090	700	1120	1400	700	4	1400
	0.50	1/2	3	1000	1250	630	780	980	630	1000	1250	630	3	1350
	0.50	1/2	2	860	1080	540	670	840	540	860	1080	540	2	1350
	0.50	1/2	1	730	900	450				730	900	450	1	1350
049	0.75	1	4	1460	1730	870	1140	1350	870	1560	1850	870	4	1850
	0.75	1	3	1300	1550	780	1020	1210	780	1400	1650	780	3	1660
	0.75	1	2	1120	1330	670	870	1040	670	1200	1430	670	2	1430
	0.75	1	1	940	1120	560				1010	1200	560	1	1350
064	0.75	1	4	1670	2050	1020	1300	1600	1020	1860	2280	1020	4	2280
	0.75	1	3	1500	1825	920	1160	1430	920	1650	2050	920	3	2040
	0.75	1	2	1280	1580	790	1000	1230	790	1430	1750	790	2	1750
	0.75	1	1	1080	1320	660				1200	1470	660	1	1470

Objectives: Select Heat Pumps
<u>**Software:** W to W</u>

Select Unit Via Drop Down Menu



Objectives: Select Heat Pumps Software

Operating Cost / 5 Ton W 2 W Versus 5 Ton W to A

Estimated Operating Cost Summary

System	Heating Cost	Cooling Cost	Hot Water Cost	Constant Fan	Total Cost	Per Month
TMW 060 110F Load / Vert 1 U-Tube - 0.75"	$1,283	$11	$162	$0	$1,455	$121
TT 064 Vspd / Vert 1 U-Tube - 0.75"	$1,226	$29	$319	$0	$1,574	$131
No Option Selected	$0	$0	$0	$0	$0	$0

Comments:
Sizing a GSHP System

1122012
MN Sizing GSHP 2012.ged

Utility Cost	Rate	Summer	Winter
Electric - Geothermal	$/kwh	.075	.075
Electric - Heat Pump	$/kwh	.075	.075
Electric - Furnace	$/kwh	.075	.075
Natural Gas	$/therm	1.00	1.00
Propane	$/gallon	2.25	2.25
Fuel Oil	$/gallon	3.00	3.00

Objectives: Design Loop System

Common Information

Loop Design

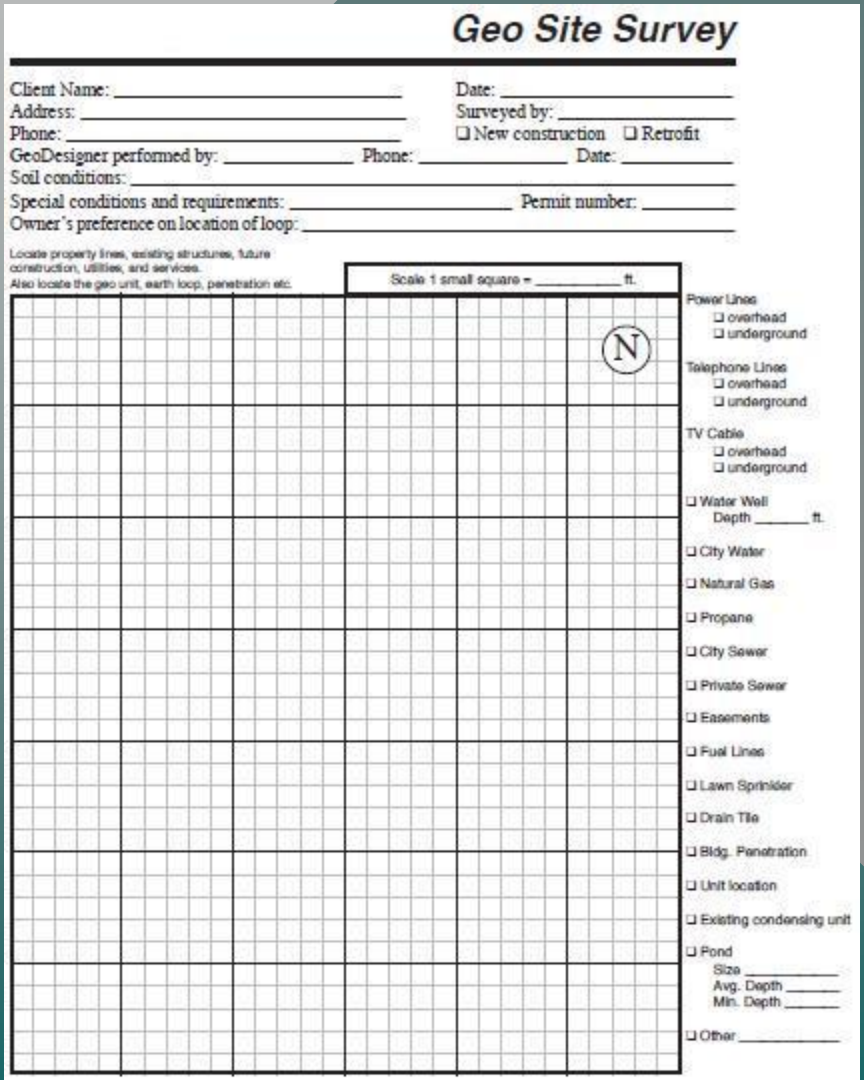
Basic Design Rules

- **3 GPM Per Ton of Equipment**
- Pressure / Temperature Ports on ALL Units

1 - 3/4" PE Circuit per ton / 3 GPM

- 1 1/4" or 2" PE Pipe for Supply & Return
- Reverse Return Header for Equal Flow

Objectives: Design Loop System
<u>**Complete a Site Survey**</u>



Geo Site Survey

Client Name: ____________ Date: ____________
Address: ____________ Surveyed by: ____________
Phone: ____________ ❑ New construction ❑ Retrofit
GeoDesigner performed by: ________ Phone: ________ Date: ________
Soil conditions: ____________
Special conditions and requirements: ____________ Permit number: ________
Owner's preference on location of loop: ____________

Locate property lines, existing structures, future construction, utilities, and services.
Also locate the geo unit, earth loop, penetration etc.

Scale 1 small square = ________ ft.

N

Power Lines
❑ overhead
❑ underground

Telephone Lines
❑ overhead
❑ underground

TV Cable
❑ overhead
❑ underground

❑ Water Well
Depth ______ ft.

❑ City Water

❑ Natural Gas

❑ Propane

❑ City Sewer

❑ Private Sewer

❑ Easements

❑ Fuel Lines

❑ Lawn Sprinkler

❑ Drain Tile

❑ Bldg. Penetration

❑ Unit location

❑ Existing condensing unit

❑ Pond
Size ________
Avg. Depth ________
Min. Depth ________

❑ Other ________

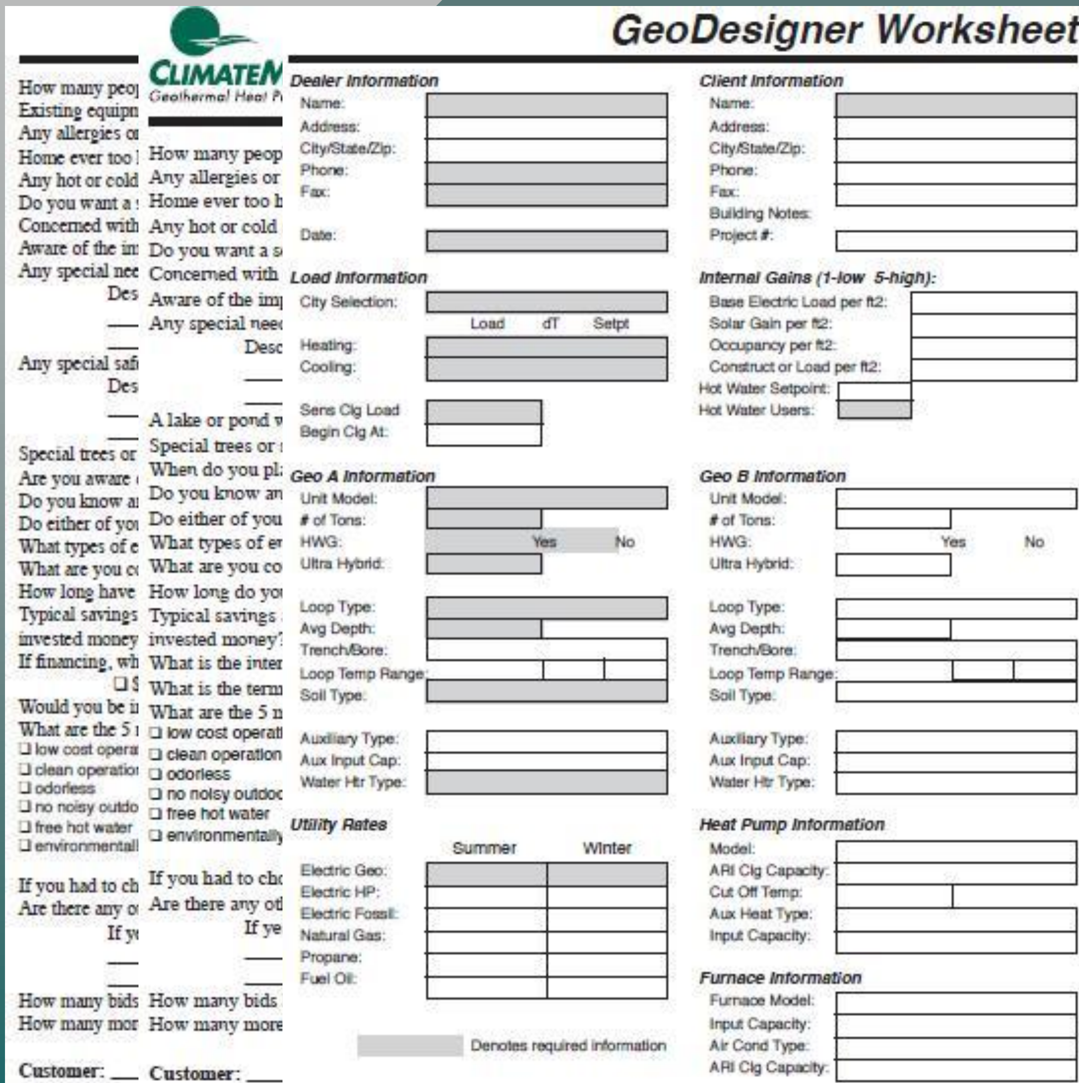
Establish Which Type of Loop Will Work best for This Design

Follow Check List on the Geo Site Survey Form

Plan a Completed "As Built" Drawing for Entire Ground Loop

Objectives: Design Loop System

Common Information


GeoDesigner Worksheet

CLIMATEM
Geothermal Heat P

Dealer Information
Name:
Address:
City/State/Zip:
Phone:
Fax:
Date:

Client Information
Name:
Address:
City/State/Zip:
Phone:
Fax:
Building Notes:
Project #:

Load Information
City Selection:
Load dT Setpt
Heating:
Cooling:
Sens Clg Load
Begin Clg At:

Internal Gains (1-low 5-high):
Base Electric Load per ft2:
Solar Gain per ft2:
Occupancy per ft2:
Construct or Load per ft2:
Hot Water Setpoint:
Hot Water Users:

Geo A Information
Unit Model:
# of Tons:
HWG: Yes No
Ultra Hybrid:
Loop Type:
Avg Depth:
Trench/Bore:
Loop Temp Range:
Soil Type:
Auxiliary Type:
Aux Input Cap:
Water Htr Type:

Geo B Information
Unit Model:
# of Tons:
HWG: Yes No
Ultra Hybrid:
Loop Type:
Avg Depth:
Trench/Bore:
Loop Temp Range:
Soil Type:
Auxiliary Type:
Aux Input Cap:
Water Htr Type:

Utility Rates

	Summer	Winter
Electric Geo:		
Electric HP:		
Electric Fossil:		
Natural Gas:		
Propane:		
Fuel Oil:		

Denotes required information

Heat Pump Information
Model:
ARI Clg Capacity:
Cut Off Temp:
Aux Heat Type:
Input Capacity:

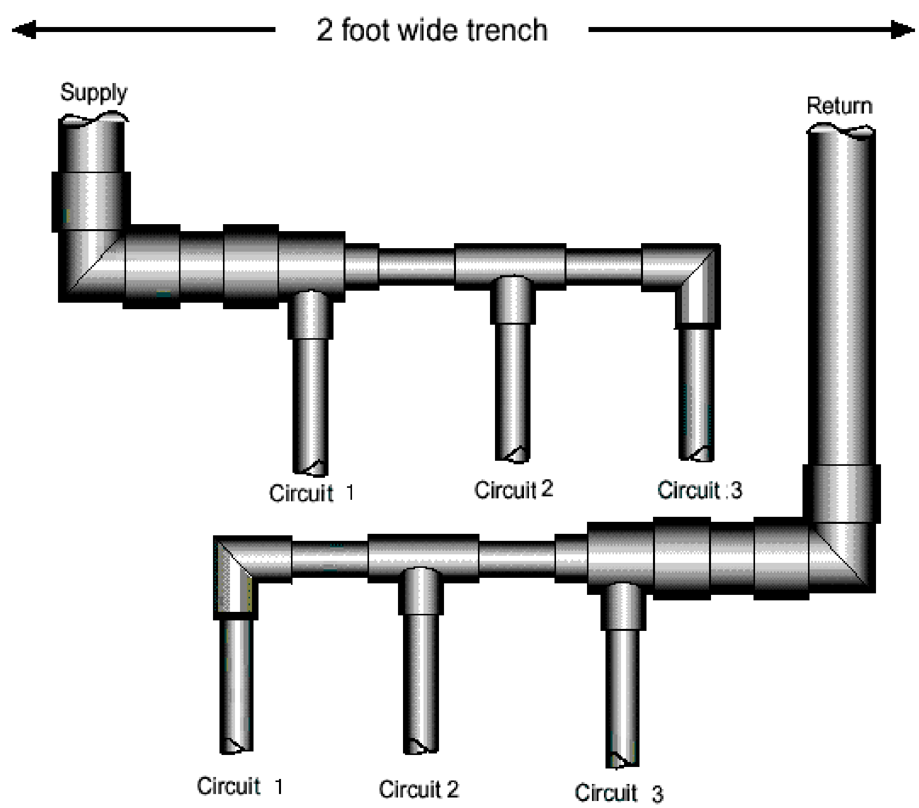
Furnace Information
Furnace Model:
Input Capacity:
Air Cond Type:
ARI Clg Capacity:

Complete the Questionnaire

Determine Proper Location and Method for Building Entry with Supply & Return Piping System And Location of Pump Station

Objectives: Design Loop System
Reverse Return

Loop Design



Objectives: Design Loop System **Vertical**

Vertical Loops

One bore per ton

Bore hole spacing 10 ft minimum

One circuit at 3 GPM flow per ton for ¾″ and 1″ circuits

U-Bend pipe sizes ¾″ & 1″ ID

ASTM PE3408 HD Geothermal PE pipe

Many states require bentonite grouting

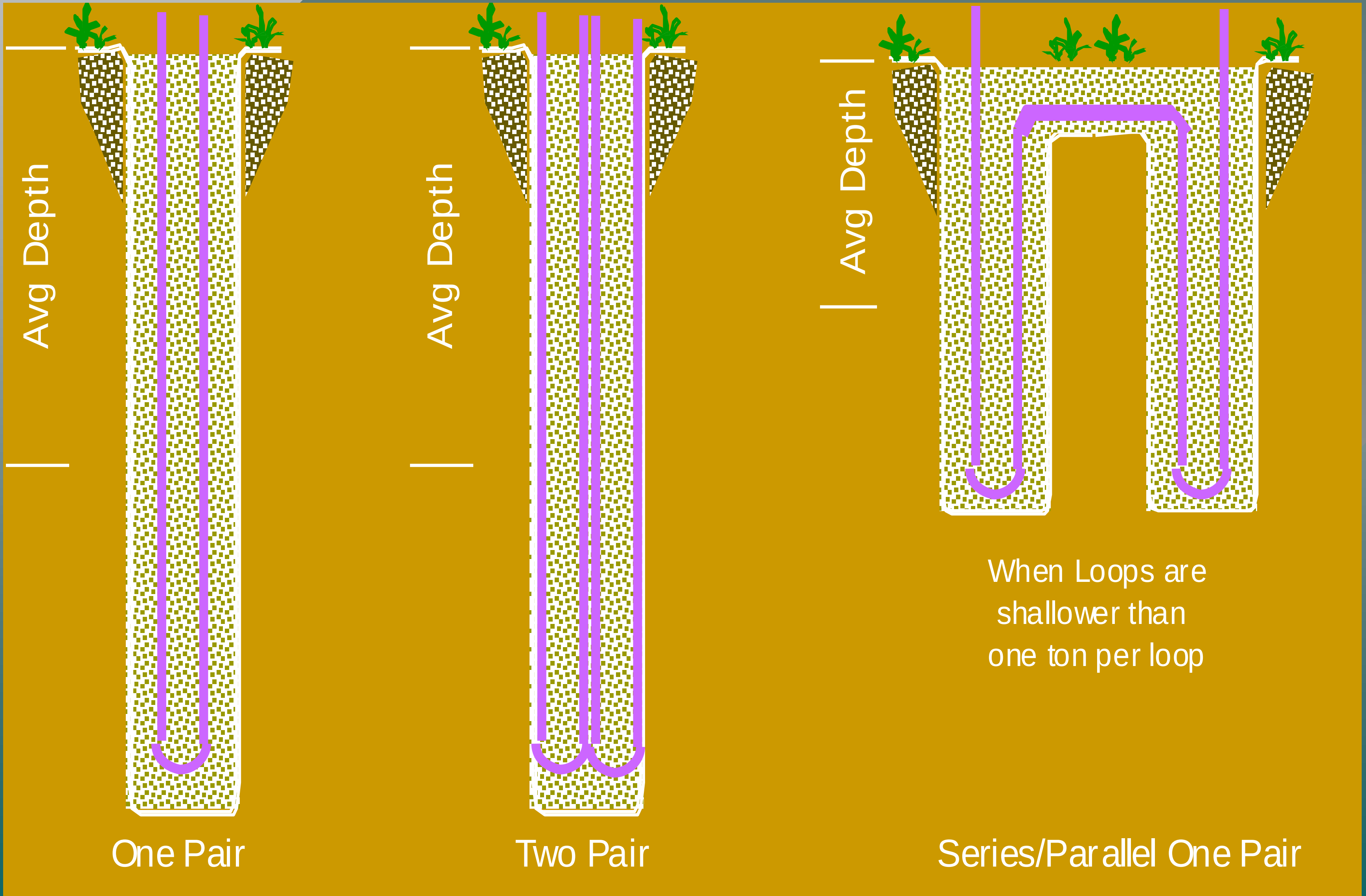
Some locales restrict drilling

Bore Hole Depth (typical)

North 150 -300 ft/ton

South 200 - 450 ft/ton

Objectives: Design Loop System
Software Program

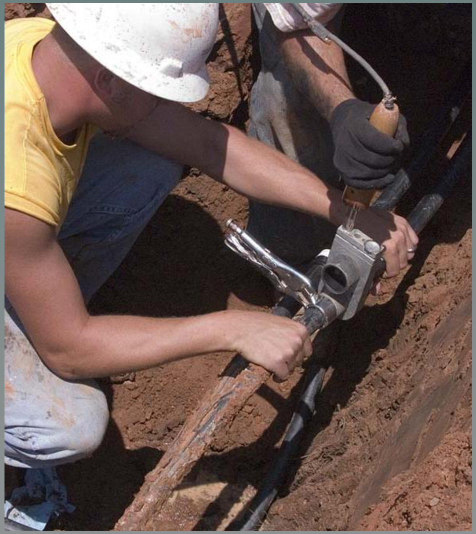


Objectives: Design Loop System

Vertical

Drilling

Pipe Loop Insertion

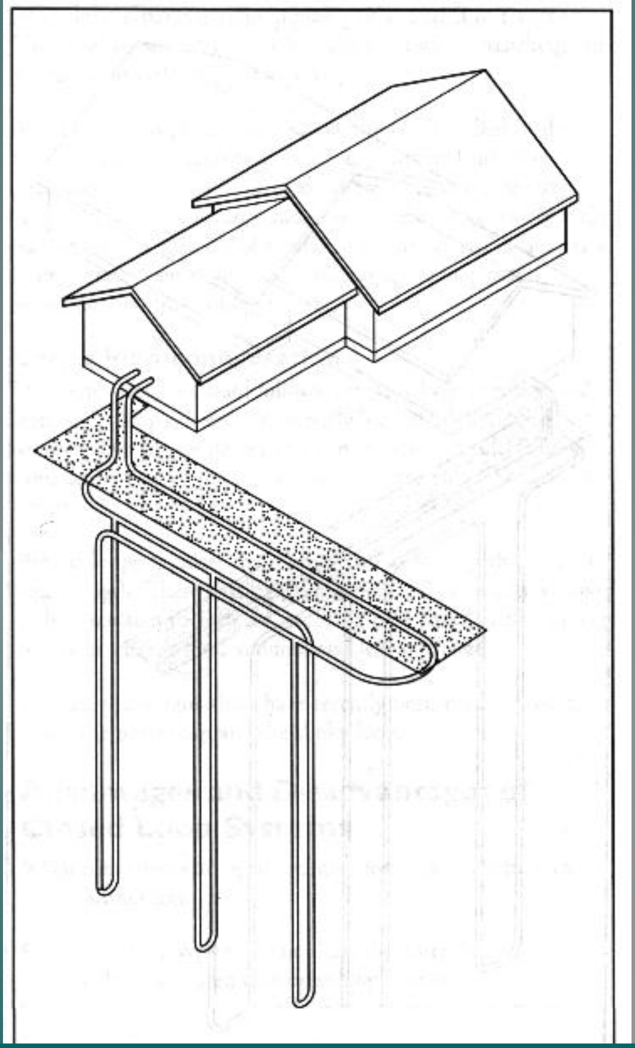


Heat Fusing

Pressure Testing

•Multiple Hole Vertical Loop

- Supply & Return Piping exit straight out from building foundations- 10 feet min.
- Header Pit should be 10 feet min. from building foundation



- Simple drawing shows typical bore hole/circuit layout.
- Actual Header Manifold less than 24” long.
- Parallel circuit piping 3/4” & 1.0” dia. Pipe sizes

Objectives: Design Loop System **Vertical**

Our 5 Ton Design with Vertical Loops

One bore per ton

Bore hole spacing 10 ft minimum

One circuit at 3 GPM flow per ton for ¾" circuits

1280 / 5 Tons = 255 Feet of Bore per Hole

5 Circuits at 510 FT each

TT 064 Vspd / Vert 1 U-Tube - 0.75"

Geothermal Source			Heating		
Bore Length:	1,280	Feet	Geothermal	3.56	COP
				93	% of Htg
				$972	Annual
Max Cooling:	63	Deg F			
Avg Cooling:	53	Deg F			
Avg Heating:	35	Deg F	Aux Heating	100	% Eff
Min Heating:	30	Deg F		7	% of Htg
				$254	Annual
Deep Earth Temp:	47	Deg F			
Soil Conductivty:	0.90		Tot Heating	$1,226	Annual
Soil Diffusivity:	0.64				

Objectives: Design Loop System **Horizontal**

Horizontal Loops

Backhoe or trench excavation

Backhoe used in areas with rock

Loop Piping installed below frost line

¾″ & 1″ ID PE3408 HD PE pipe

1 circuit per ton using ¾″ and 1″ circuits

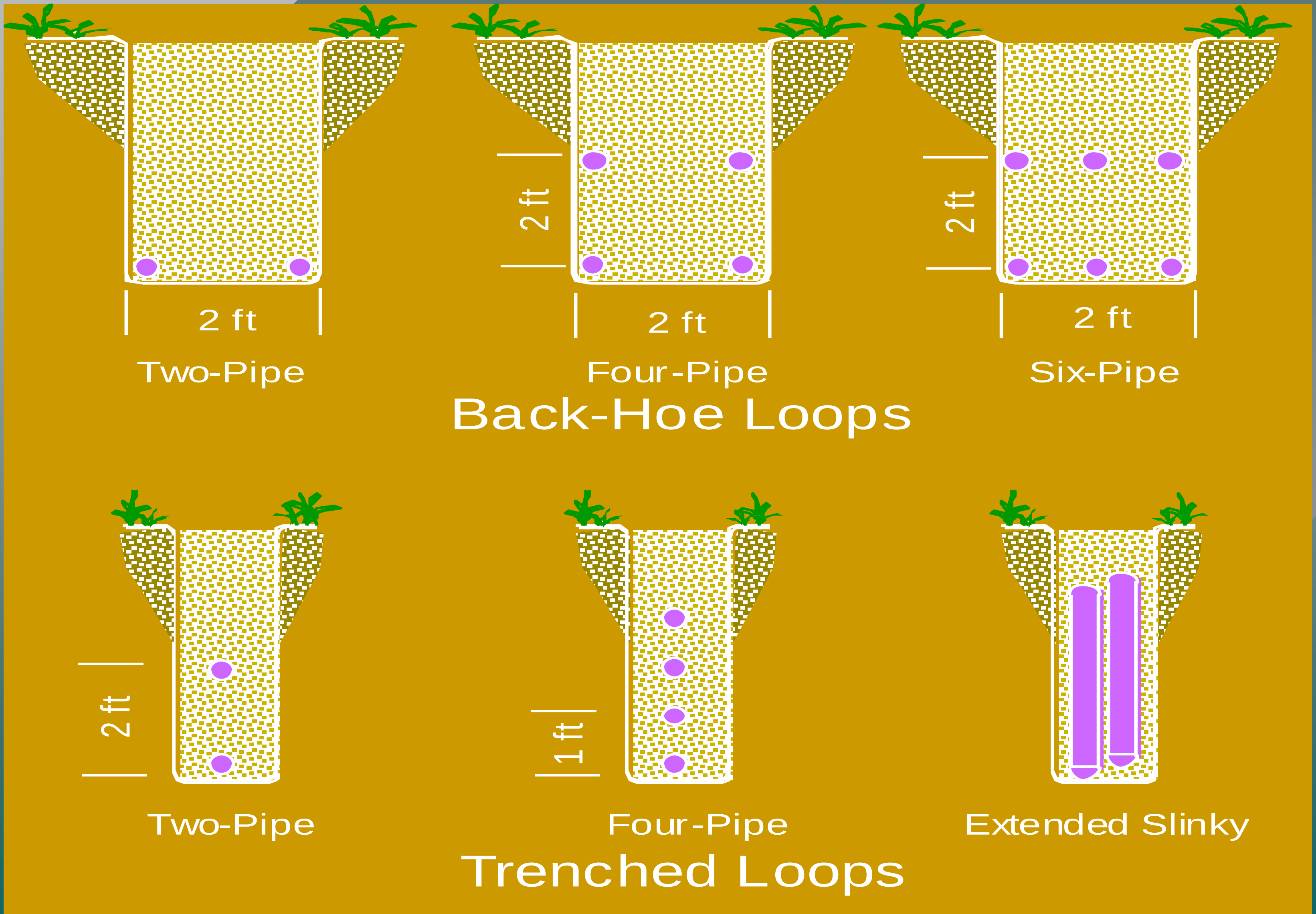
3 gpm flow/ton

Pipe per ton

North 600 ft - 1200 ft

South 700 ft - 1800 ft

Objectives: Design Loop System
Software Program



Objectives: Design Loop System

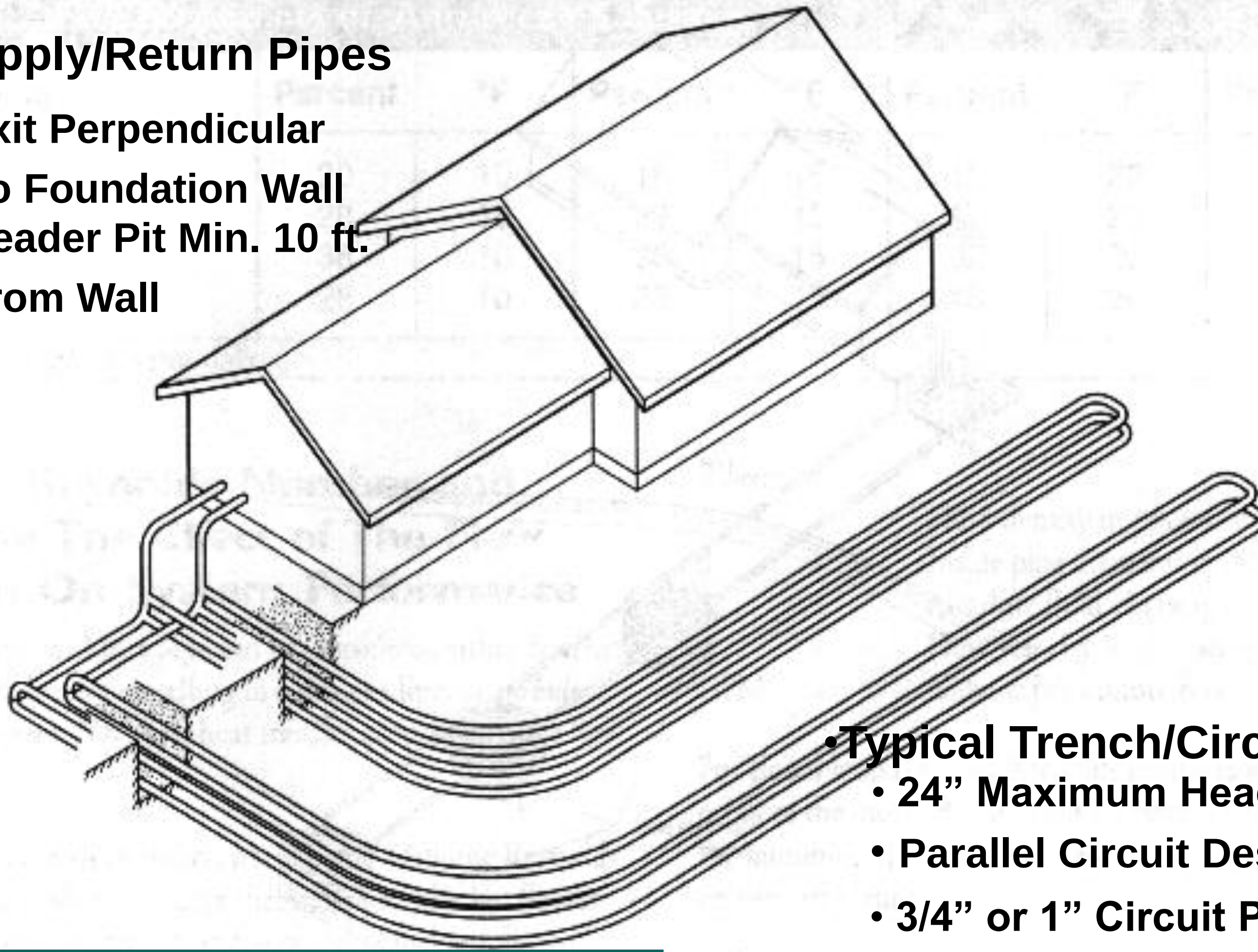
Trenching

Pit Loops

Horizontal Boring

Four-Pipe Horizontal Loop

- Supply/Return Pipes
  - Exit Perpendicular
  - to Foundation Wall
  - Header Pit Min. 10 ft.
  - from Wall



- Typical Trench/Circuit layout
  - 24” Maximum Header/Manifold
  - Parallel Circuit Design
  - 3/4” or 1” Circuit Pipe

Objectives: Design Loop System

<u>**Horizontal Trench**</u>

Our 5 Ton Design with a 4 pipe Horizontal Loop

OPTION # 1

Backhoe or trench excavation

1 circuit per ton using ¾” circuits

8 feet AVG Depth

870 total feet / 2 = 2 trenches at 435 feet each

<u>4 Circuits</u> at 900 FT each

TT 064 Vspd and Horz 4 pipe - 0.75"

Geothermal Source			Heating		
Trench Length:	870	Feet	Geothermal	3.66	COP
				95	% of Htg
Max Cooling:	64	Deg F		$963	Annual
Avg Cooling:	52	Deg F			
Avg Heating:	38	Deg F	Aux Heating	100	% Eff
Min Heating:	30	Deg F		5	% of Htg
				$193	Annual
Deep Earth Temp:	47	Deg F			
Soil Conductivty:	0.90		Tot Heating	$1,157	Annual
Soil Diffusivity:	0.64				

OPTION # 2

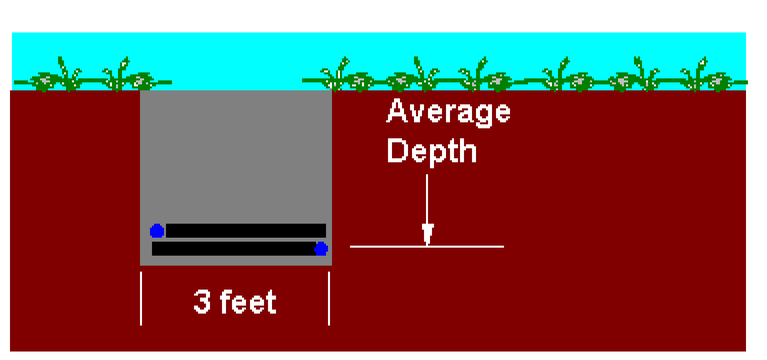
1 circuit per ton using ¾” circuits

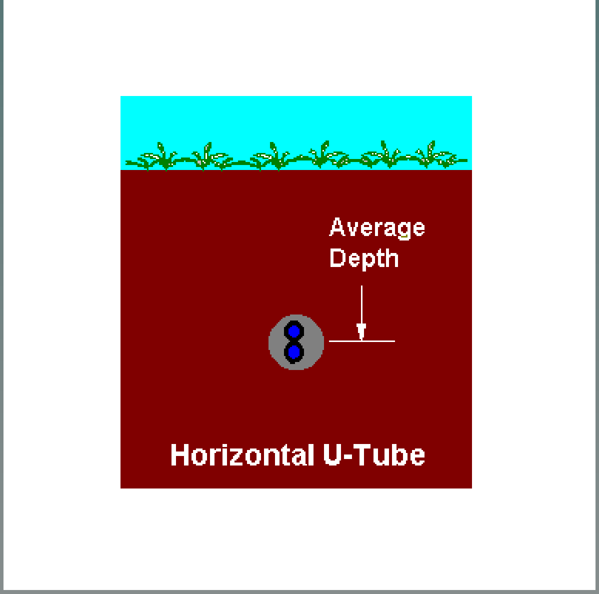
870 total feet / 3 = 3 trenches at 290 feet each

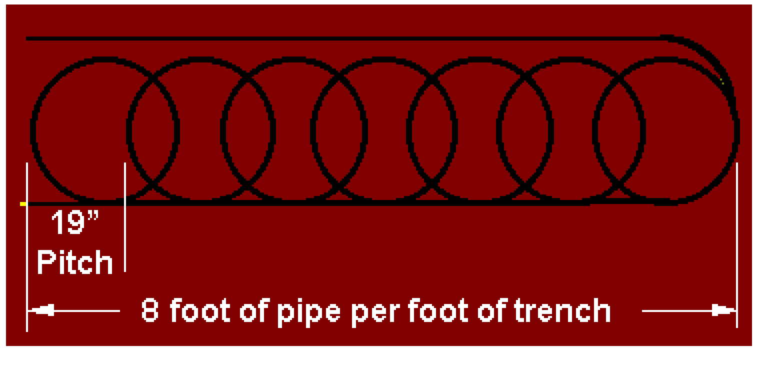
<u>6 Circuits</u> at 600 FT each

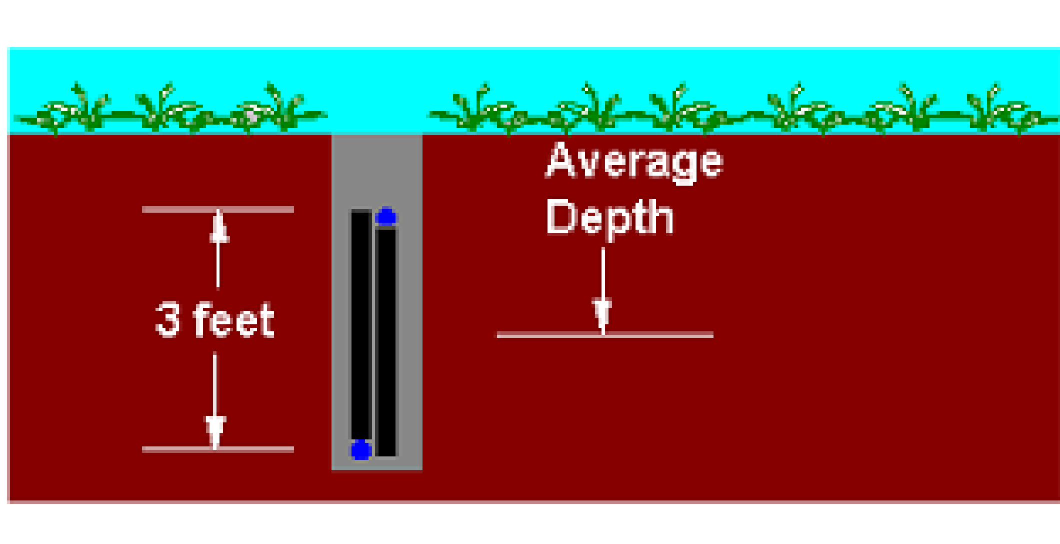
Objectives: Design Loop System **Software Program**

Slinky Horizontal and Bore Loops









Objectives: Design Loop System
Horizontal Bore

Our 5 Ton Design with a Horizontal Bore Loop

Horizontal Bore

1 circuit per ton using ¾” circuits

15 feet AVG Depth

1,100 total feet / 5 = 5 trenches at 220 feet each

5 Circuits at 440 Ft each

TT 064 Vspd and Horz U-Tube - 0.75"

Geothermal Source			**Heating**		
Bore Length:	1,100	Feet	Geothermal	3.64	COP
				94	% of Htg
Max Cooling:	64	Deg F		$960	Annual
Avg Cooling:	51	Deg F			
Avg Heating:	37	Deg F	Aux Heating	100	% Eff
Min Heating:	30	Deg F		6	% of Htg
				$226	Annual
Deep Earth Temp:	47	Deg F			
Soil Conductivty:	0.90		Tot Heating	$1,186	Annual
Soil Diffusivity:	0.64				

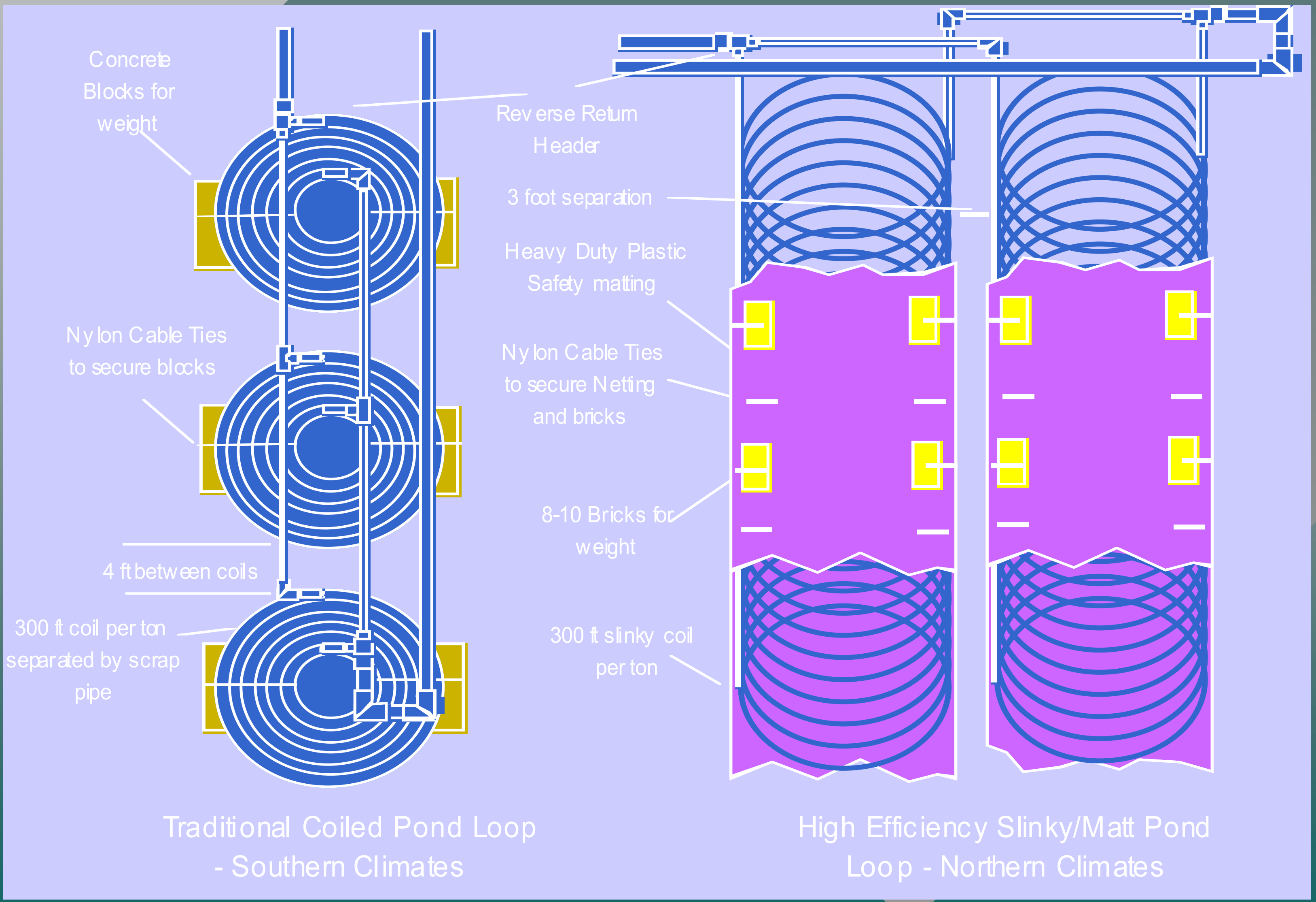
Objectives: Design Loop System
Pond / Lake

Lake or Pond Loop

- Least expensive ground loop
- **Minimum 1/2 acre and 10 feet deep**
- Pond should be within 400’ of structure
- In North - need ice cover for good operation
  - Utilizes 39°F water temp (no aeration).
  - Stagnate water body works best for heating
- Pipe footage per ton / circuit
  - North and South 400 ft -500 ft/ton
  - 3/4” ASTM PE3408 HD PE pipe

Objectives: Design Loop System

Pond / Lake



Lake Loop Coils on Rack

Objectives: Design Loop System

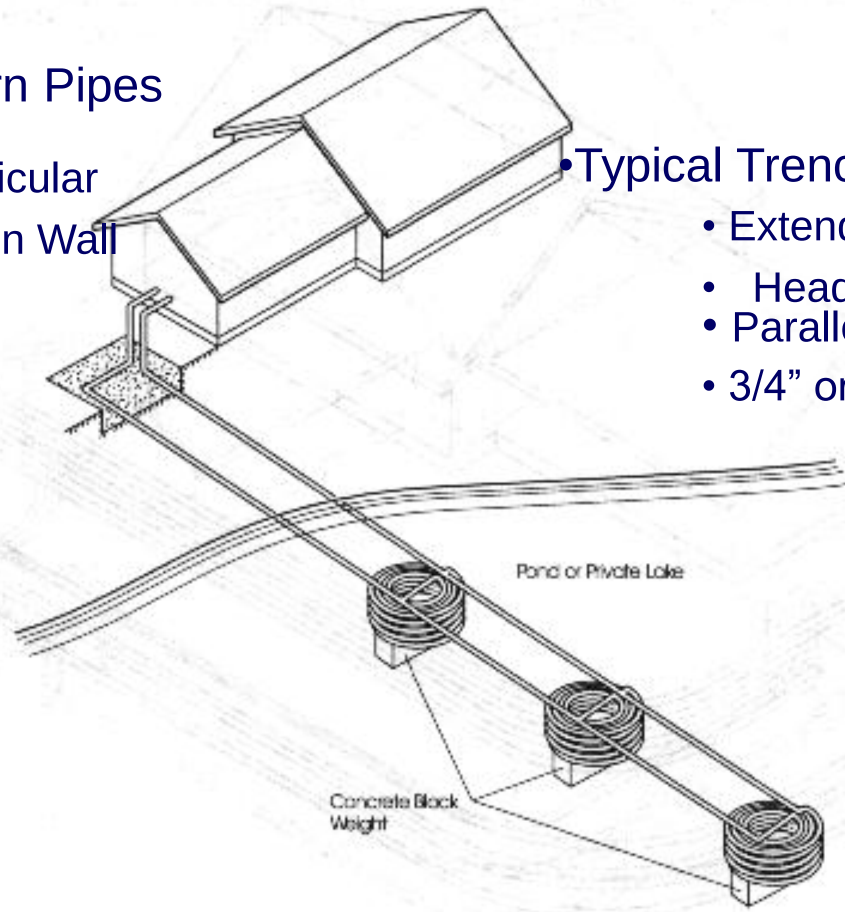
Pond / Lake

Plate Heat Exchangers

Floating Coils

Pond Loop Layout

- Supply/Return Pipes
  - Exit Perpendicular
  - to Foundation Wall



- Typical Trench/Circuit layout
  - Extended Reverse Return
  - Header/Manifold
  - Parallel Circuit Design
  - 3/4” or 1” HD PE3408 pipe

Objectives: Design Loop System
<u>**Pond / Lake**</u>

One Circuit per ton

Lake or Pond Loop

Some spacing required between coils or slinky

<u>USE</u> - **One circuit per Ton at 400 FEET and 3 GPM flow per ton for ¾” circuits**

TT 064 Vspd and Pond Loop - Coiled 0.75"

Geothermal Source		
Pipe Length:	1,500	Feet
Max Cooling:	76	Deg F
Avg Cooling:	65	Deg F
Avg Heating:	34	Deg F
Min Heating:	29	Deg F
Deep Earth Temp:	47	Deg F
Soil Conductivty:	0.00	
Soil Diffusivity:	0	

Heating		
Geothermal	3.54	COP
	94	% of Htg
	$983	Annual
Aux Heating	100	% Eff
	6	% of Htg
	$234	Annual
Tot Heating	$1,218	Annual

2000 / 5 Tons = 400 Feet of PE Pipe per Circuit w 5 Total

Heating Dominant Loads in a Northern Climate Should USE 400 Feet of ¾” PE Pipe per Ton / Not 300’ / Ton

<u>**Minimum 1/2 acre / 24,000 SQ FT and a MINIMUM of 10 feet deep**</u>

Quick Connect Test Caps – Examples (McElroy Mfg.)

Water Side Of System

Flow Controller / Pump Station

Water Side Of System

Non Pressurized Pump Station

QT® Flow Center

Objectives: Select Loop Circulator Pumps

Pump Selection

Pump Selection

- Verify 1 or 2 Pump Flow Controller
- **1 Pump = 3 Ton Unit**
- **2 Pump = 3.5 to 6 Tons**
- Minimum Flow of 2.25 GPM / Ton
- Verify Reynolds Number at 2500 Min.
- Use Pressure Drop Software Program
- Flush Cart Capable of Proper Flow

Objectives: Effects on Loop Software

Total Bore 4 Ton, 5 Ton VS 6 Ton

TT 049 Vspd /

Geothermal Source	
Bore Length:	1,010 Feet
Max Cooling:	68 Deg
Avg Cooling:	56 Deg
Avg Heating:	33 Deg
Min Heating:	30 Deg
Deep Earth Temp:	47 Deg
Soil Conductivty:	0.90
Soil Diffusivity:	0.64

TT 064 Vspd / V

Geothermal Source	
Bore Length:	1,280 Feet
Max Cooling:	63 Deg F
Avg Cooling:	53 Deg F
Avg Heating:	35 Deg F
Min Heating:	30 Deg F
Deep Earth Temp:	47 Deg F
Soil Conductivty:	0.90
Soil Diffusivity:	0.64

TT 072 Vspd / Vert

Geothermal Source	
Bore Length:	1,315 Feet
Max Cooling:	62 Deg F
Avg Cooling:	53 Deg F
Avg Heating:	36 Deg F
Min Heating:	30 Deg F
Deep Earth Temp:	47 Deg F
Soil Conductivty:	0.90
Soil Diffusivity:	0.64

Objectives: Select Loop Circulator Pumps

Vertical Example with Methanol

Version 8.1

rev. 081809

CLIMATEMASTER
Geothermal Heat Pump Systems

Geothermal Closed Loop Pressure Drop Calculation Worksheet

3. Inside
Pipe s

4. Outsi
Pipe s

5. Circui
Pipe s

6. Fitting

7. Total

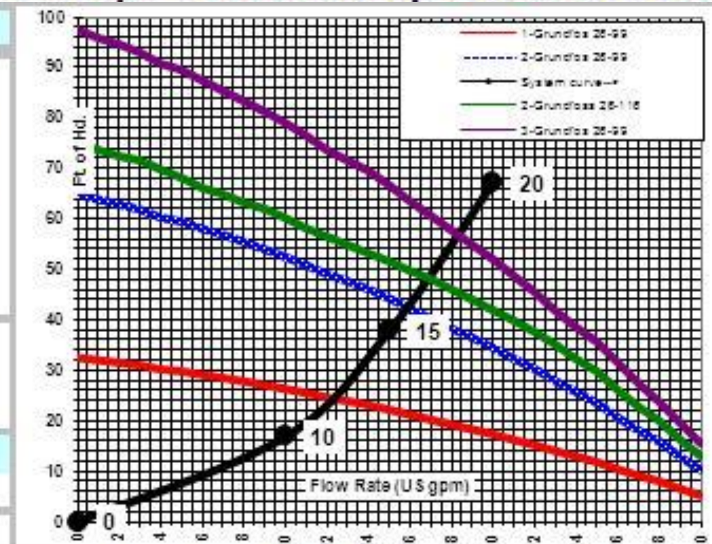
Minimum system flow rate should be 11 gpm.

8. Determine Pump Sizing Curve Coordinates:

Tot. gpm (3 gpm/ton) =	Q1	15.0	x	point A
Tot. pres. drop (Ft hd)=	h1	37.7	y	
Tot. gpm **x** 2/3 =	Q2	10.0	x	point B
PD=(Q2^2)(h1)/(Q1^2)	h2	16.8	y	
Tot. gpm **x** 4/3 =	Q3	20.0	x	point C
PD=(Q3^2)(h1)/(Q1^2)	h3	67.1	y	

9. Plot system curve & determine which Flow Controller will produce the desired flow rate.
Pump Sys B = 16 gpm (to the nearest gpm)

10. Verify circuit Reynolds number: 3578
(Should be 2,500 or greater)



___ ft. of hd. B

___ ft. of hd. C

series loop):
2 gpm
___ ft. of hd. D

___ ft. of hd. E

___ ft. of hd.** F

11. Calculate the amount of antifreeze needed:

(Pipe size:	1.00)	10	tot. feet* **x**	4.5	volume/100 ft. ÷ 100 =	0.5 gallons
(Pipe size:	1.25)	200	tot. feet* **x**	8.3	volume/100 ft. ÷ 100 =	16.6 gallons
(Pipe size:	0.75)	2550	tot. feet* **x**	2.8	volume/100 ft. ÷ 100 =	71.4 gallons
(Pipe size:			tot. feet* **x**	-	volume/100 ft. ÷ 100 =	- gallons

Notes: 1) Use decimal number for pipe size (e.g. 3/4" = 0.75)
2) Volume/100 ft. is shown for PE pipe only.
3) Use 1" pipe for rubber hose.

Total fluid in loop: 99.5 gallons**
% antifreeze **x** 25% by vol.
Total antifreeze req.: 24.9 gallons

12. Determine Flushing Requirements.
Flushing requirements: 20 gpm @ 67 ft. hd.

Objectives: Select Loop Circulator Pumps

Vertical Example with Propylene Glycol

Customer: MN GSHPA 2012
Address: 5 Ton Vertical Example
Address:

Antifreeze (M,P,E or W)[1]: P Propylene Glycol
% Antifreeze by vol.: 25 %
Number of circuits: 4
Pump combinaton:[2] C (2) UP26-116

[1]Note: M = Methanol; P = Propylene Glycol; E = Ethanol; W = Water
[2]Note: Pump combo A = 1-UP26-99; pump combo B = 2-UP26-99; pump combo C = 2-UP26-116; pump combo D = 3-UP26-99

1. Unit #1: 4 (enter code from below) TT_064 5 tons gpm 15

7. Total Pressure Drop (A + B + C + D + E): 46.4 ft. of hd.** F

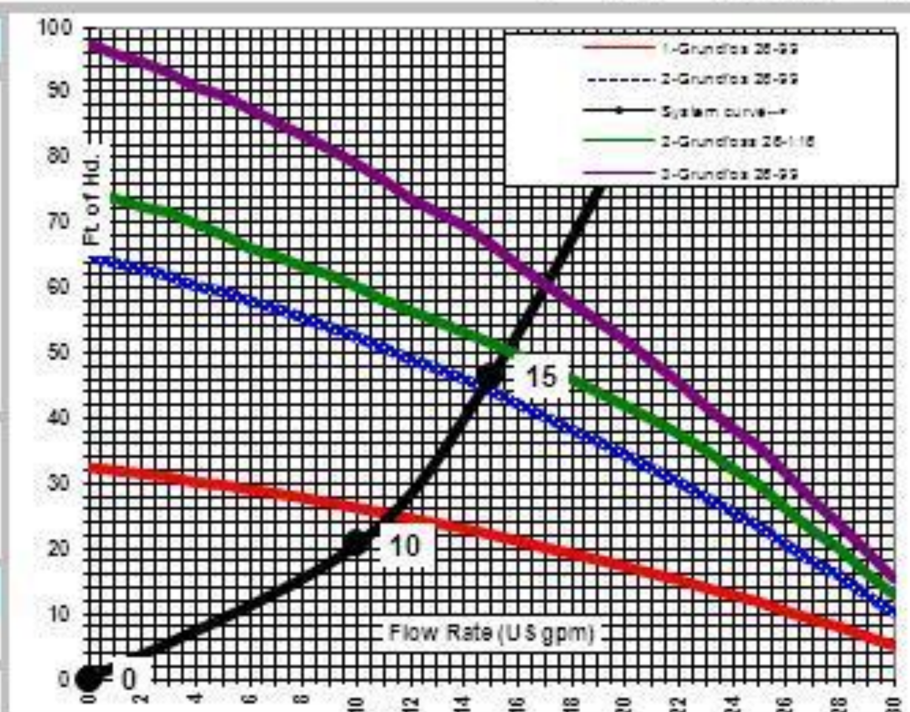
Minimum system flow rate should be 11 gpm.

8. Determine Pump Sizing Curve Coordinates:

Tot. gpm (3 gpm/ton) =	Q1	15.0	x	point A
Tot. pres. drop (Ft hd)=	h1	46.4	y	
Tot. gpm x 2/3 =	Q2	10.0	x	point B
PD=(Q2^2)(h1)/(Q1^2)	h2	20.6	y	
Tot. gpm x 4/3 =	Q3	20.0	x	point C
PD=(Q3^2)(h1)/(Q1^2)	h3	82.5	y	

9. Plot system curve & determine which Flow Controller will produce the desired flow rate.
Pump Sys C = 16 gpm (to the nearest gpm)

10. Verify circuit Reynolds number: 2554
(Should be 2,500 or greater)



Objectives: Select Loop Circulator Pumps

Horizontal 4 Pipe w 4 Circuits Example

Customer: MN GSHPA 2012 — Antifreeze (M,P,E or W): M Methanol

Address: 5 Ton Horizontal 4 Pipe Example — % Antifreeze by vol.: 25 %

Address: With 4 Circuits — Number of circuits: 4

6. Fittings (Add 2 ft. of hd.for every 10 fittings): 18 (number of fittings) 3.6 ft. of hd. E

7. Total Pressure Drop (A + B + C + D + E): 58.1 ft. of hd.** F

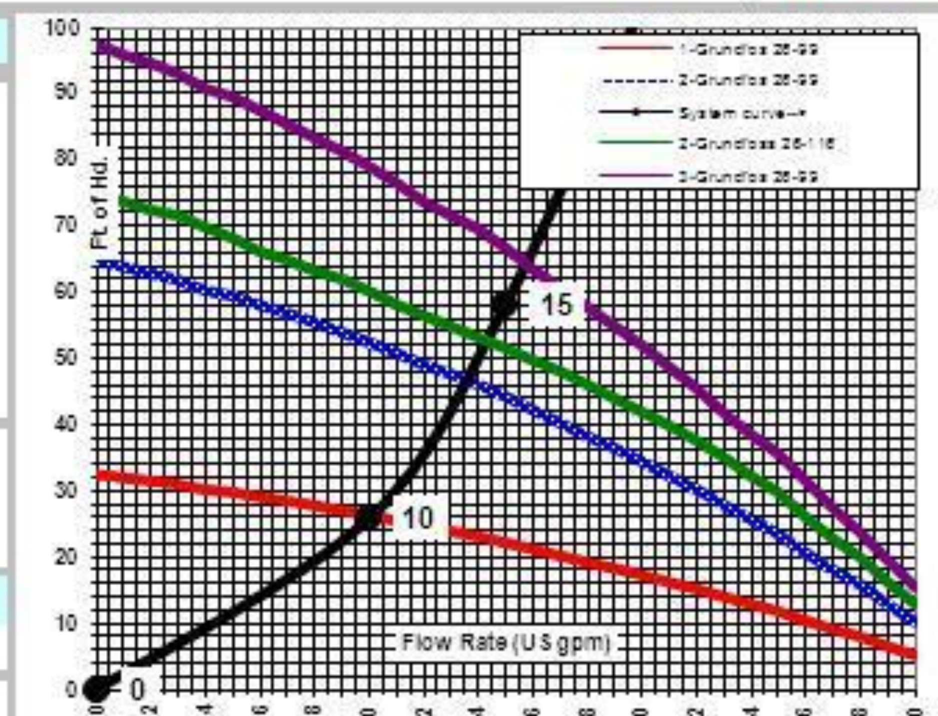
Minimum system flow rate should be 11 gpm.

8. Determine Pump Sizing Curve Coordinates:

Tot. gpm (3 gpm/ton) =	Q1	15.0	x	point A
Tot. pres. drop (Ft hd)=	h1	58.1	y	
Tot. gpm **x** 2/3 =	Q2	10.0	x	point B
PD=(Q2^2)(h1)/(Q1^2)	h2	25.8	y	
Tot. gpm **x** 4/3 =	Q3	20.0	x	point C
PD=(Q3^2)(h1)/(Q1^2)	h3	103.4	y	

9. Plot system curve & determine which Flow Controller will produce the desired flow rate. Pump Sys B = 13 gpm (to the nearest gpm)

10. Verify circuit Reynolds number: 3690 (Should be 2,500 or greater)



Pipe size: 0.75 in. Design GPM/ckt: 3.8 Actual GPM/ckt = 3.5 gpm

900 ft. of pipe* x 3.68 ft. of hd/100 ft. ÷ 100 = 33.12 ft. of hd. D

Objectives: Select Loop Circulator Pumps

Horizontal 4 Pipe w 6 Circuits Example

Customer: MN GSHPA 2012 — Antifreeze (M,P,E or W)[1]: M Methanol

Address: 5 Ton Horizontal 4 Pipe Example — % Antifreeze by vol.: 25 %

Address: With 4 Circuits — Number of circuits: 6

[1]Note: M = Methanol; P = Propylene Glycol; E = Ethanol; W = Water — Pump combinaton:[2] B (2) UP26-99

7. Total Pressure Drop (A + B + C + D + E): 35.9 ft. of hd.** F

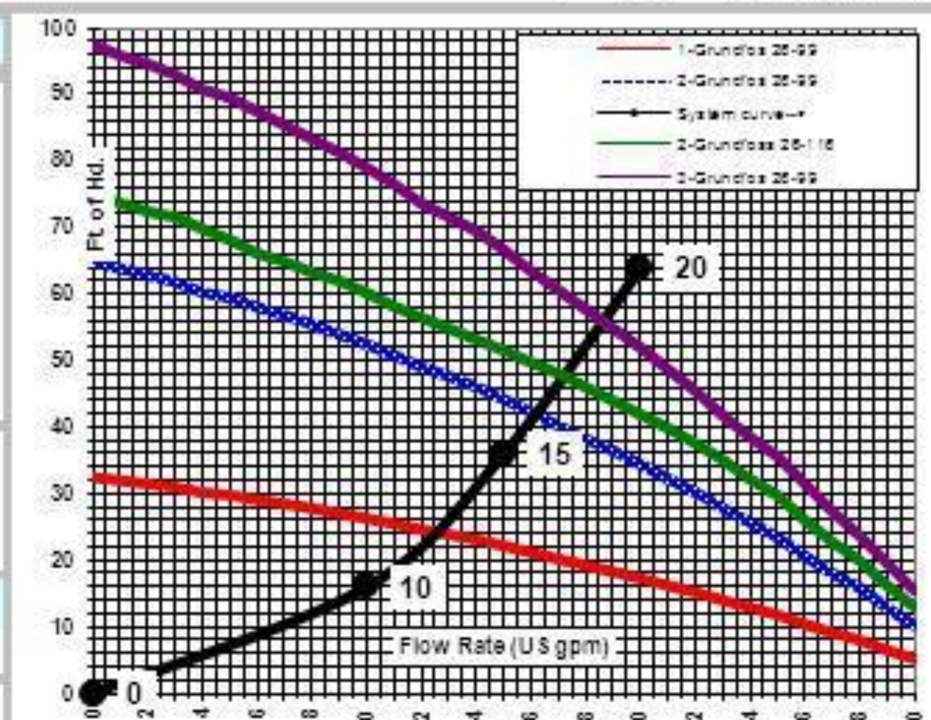
Minimum system flow rate should be 11 gpm.

8. Determine Pump Sizing Curve Coordinates:

Tot. gpm (3 gpm/ton) =	Q1	15.0	x	point A
Tot. pres. drop (Ft hd)=	h1	35.9	y	
Tot. gpm x 2/3 =	Q2	10.0	x	point B
PD=(Q2^2)(h1)/(Q1^2)	h2	15.9	y	
Tot. gpm x 4/3 =	Q3	20.0	x	point C
PD=(Q3^2)(h1)/(Q1^2)	h3	63.8	y	

9. Plot system curve & determine which Flow Controller will produce the desired flow rate.
Pump Sys B = 16 gpm (to the nearest gpm)

10. Verify circuit Reynolds number: 3019
(Should be 2,500 or greater)



Pipe size: 0.75 in. Design GPM/ckt: 2.5 *Actual GPM/ckt =* 2.7 *gpm*

600 ft. of pipe* x 1.81 ft. of hd/100 ft. ÷ 100 = 10.86 ft. of hd. D

Objectives: Select Loop Circulator Pumps

Lake Loop w 4 Circuits Example

5. Circuit Piping (Use only one circuit if piped using parallel header system; use total pipe if series loop):
   Pipe size: 0.75 in. Design GPM/ckt: 3.8 *Actual GPM/ckt = 4.0 gpm*
   500 ft. of pipe* **x** 4.23 ft. of hd/100 ft. ÷ 100 = 21.17 ft. of hd. D

6. Fittings (Add 2 ft. of hd.for every 10 fittings): 18 (number of fittings) 3.6 ft. of hd. E

7. Total Pressure Drop (A + B + C + D + E): 43.4 ft. of hd.** F

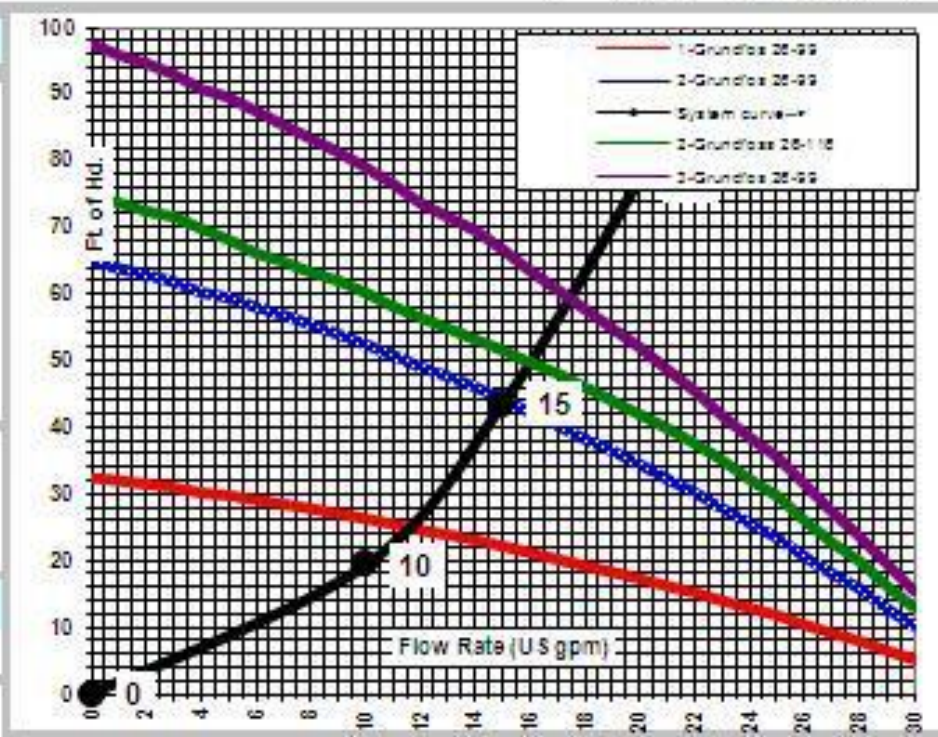
Minimum system flow rate should be 11 gpm.

8. Determine Pump Sizing Curve Coordinates:

Tot. gpm (3 gpm/ton) =	Q1	15.0	x	point A
Tot. pres. drop (Ft hd)=	h1	43.4	y	
Tot. gpm **x** 2/3 =	Q2	10.0	x	point B
PD=(Q2^2)(h1)/(Q1^2)	h2	19.3	y	
Tot. gpm **x** 4/3 =	Q3	20.0	x	point C
PD=(Q3^2)(h1)/(Q1^2)	h3	77.2	y	

9. Plot system curve & determine which Flow Controller will produce the desired flow rate.
   Pump Sys C = 16 gpm (to the nearest gpm)

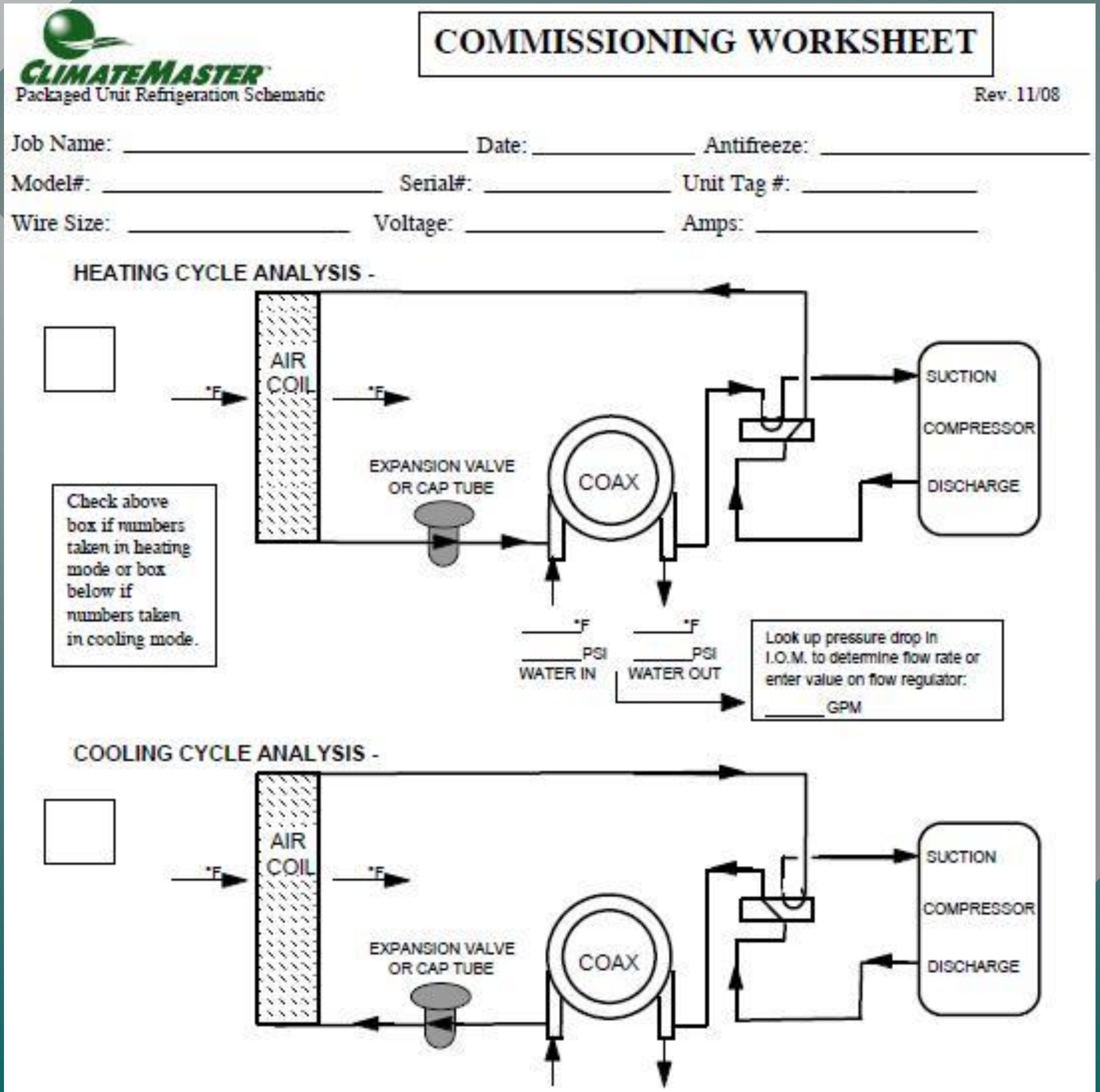
10. Verify circuit Reynolds number: 2554
    (Should be 2,500 or greater)



500 ft. of pipe* x 0.74 ft. of hd/100 ft. ÷ 100 = 3.72 ft. of hd. C

Objectives: System Performance Evaluation

Each Unit MUST Have Proper Startup

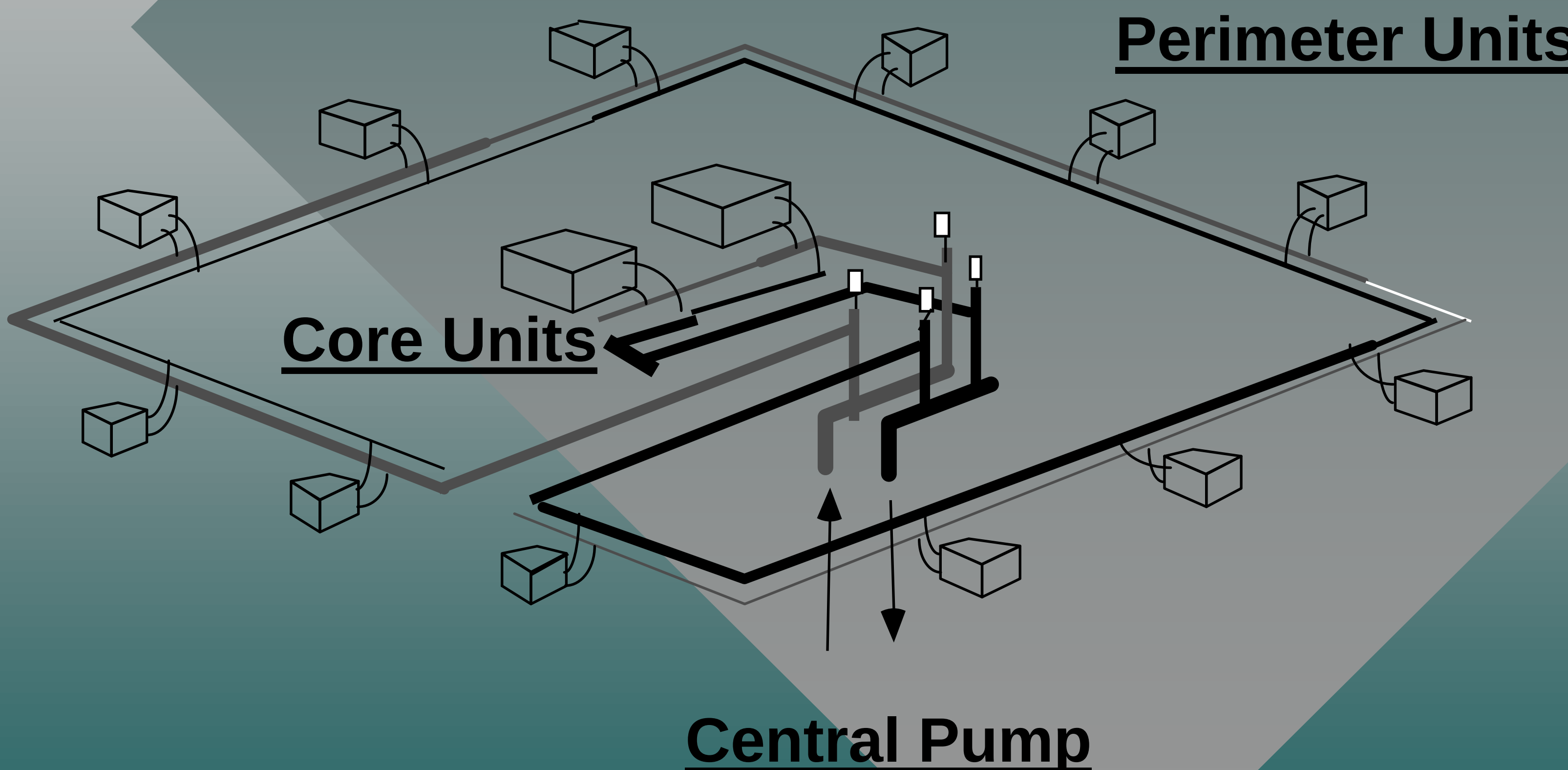


Objectives: Building Loads Commercial

- Commercial - Calculate Building Loads using ACCA Manual N or ASHRAE Method
- Zone loads are used to select heat pumps
- Peak block load is used to determine bore loop depths
- Heating and cooling loads are required for each zone / area that will have a ground loop system
- Commercial Building Load Profile is "Normally" Cooling Dominate

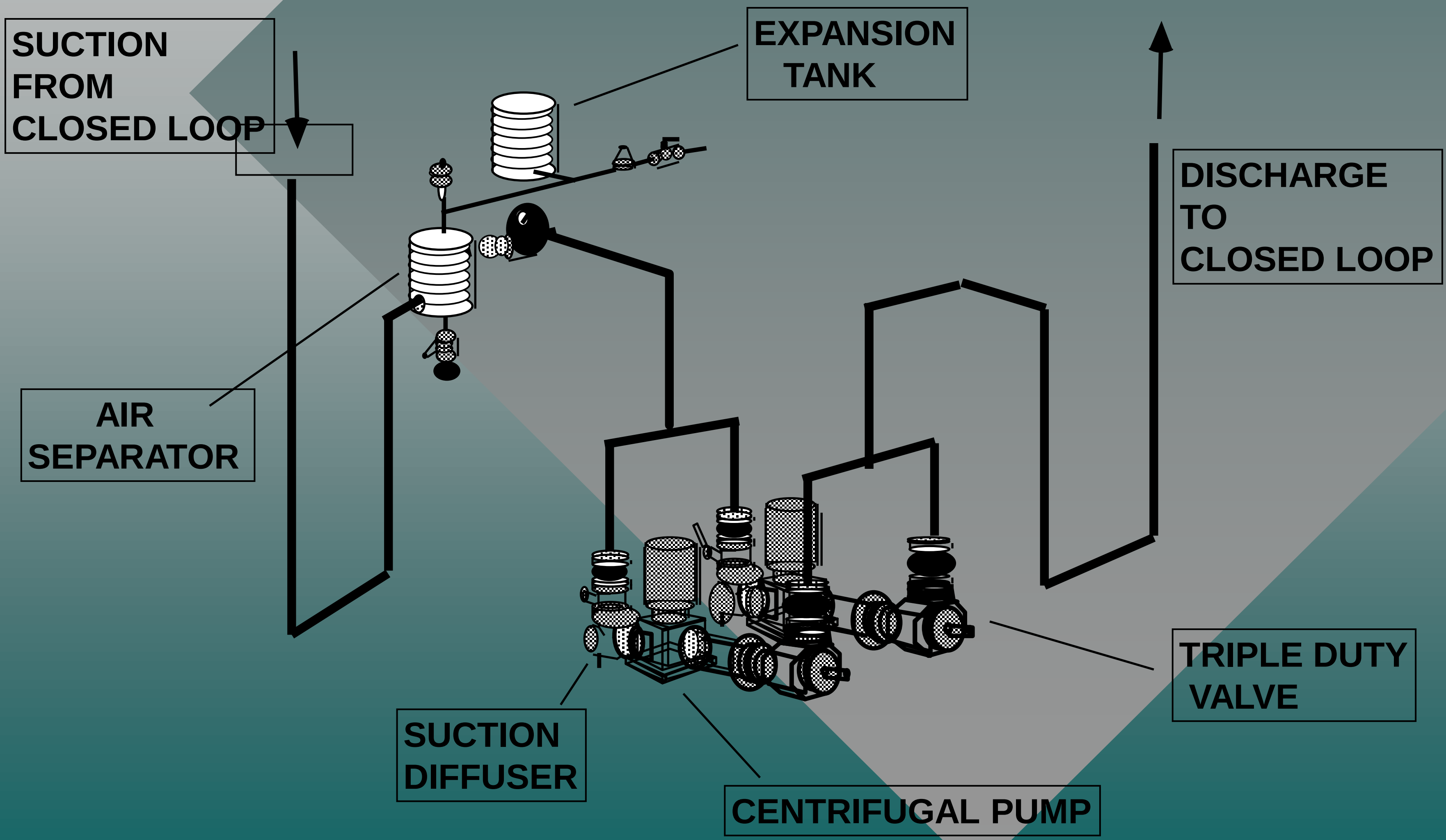
Objectives: Building Loads Commercial

UNIT LAYOUT- PERIMETER AND CORE DESIGN



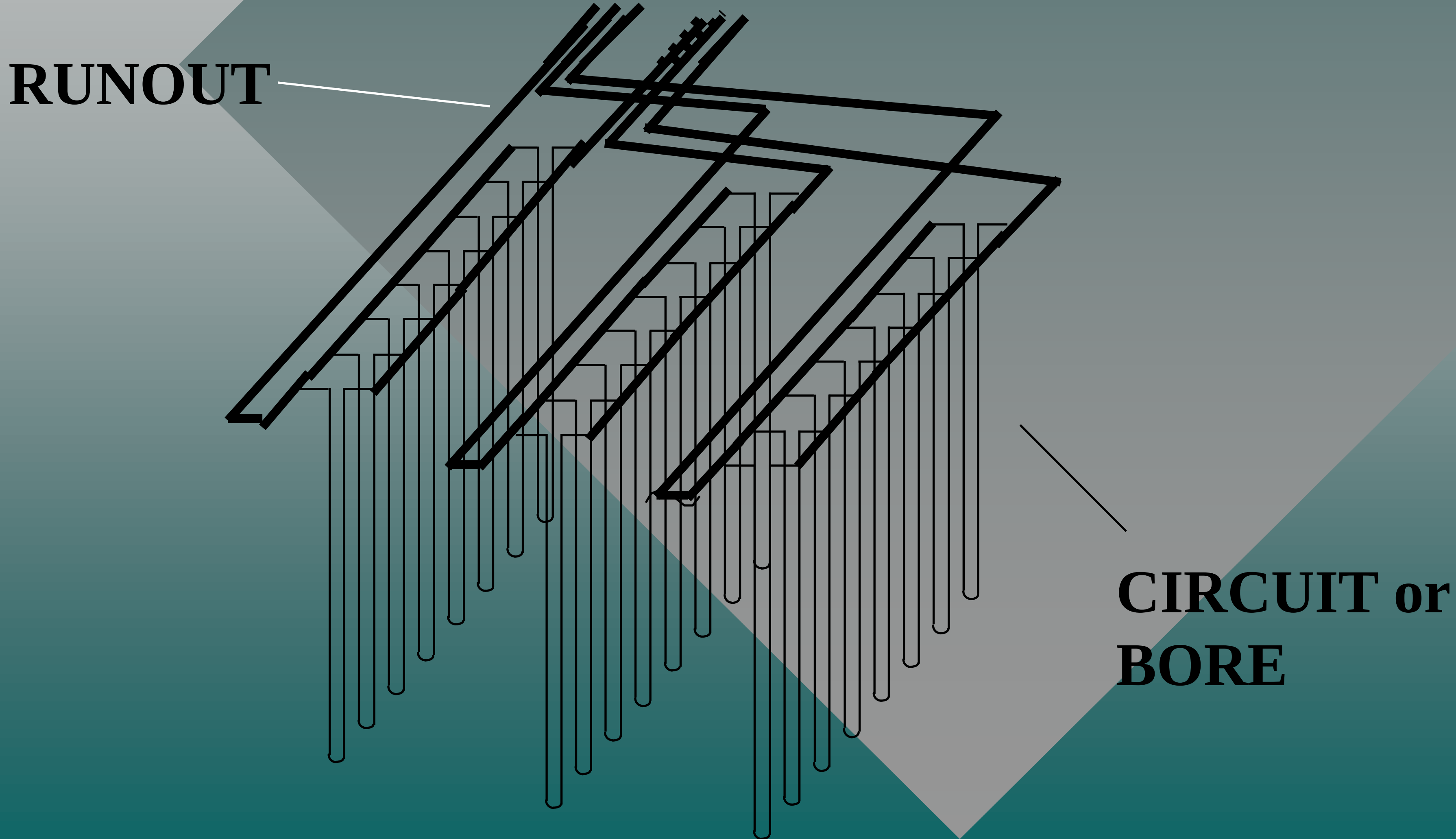
Objectives: Building Loads Commercial

CENTRAL PUMP STATION APPLICATION



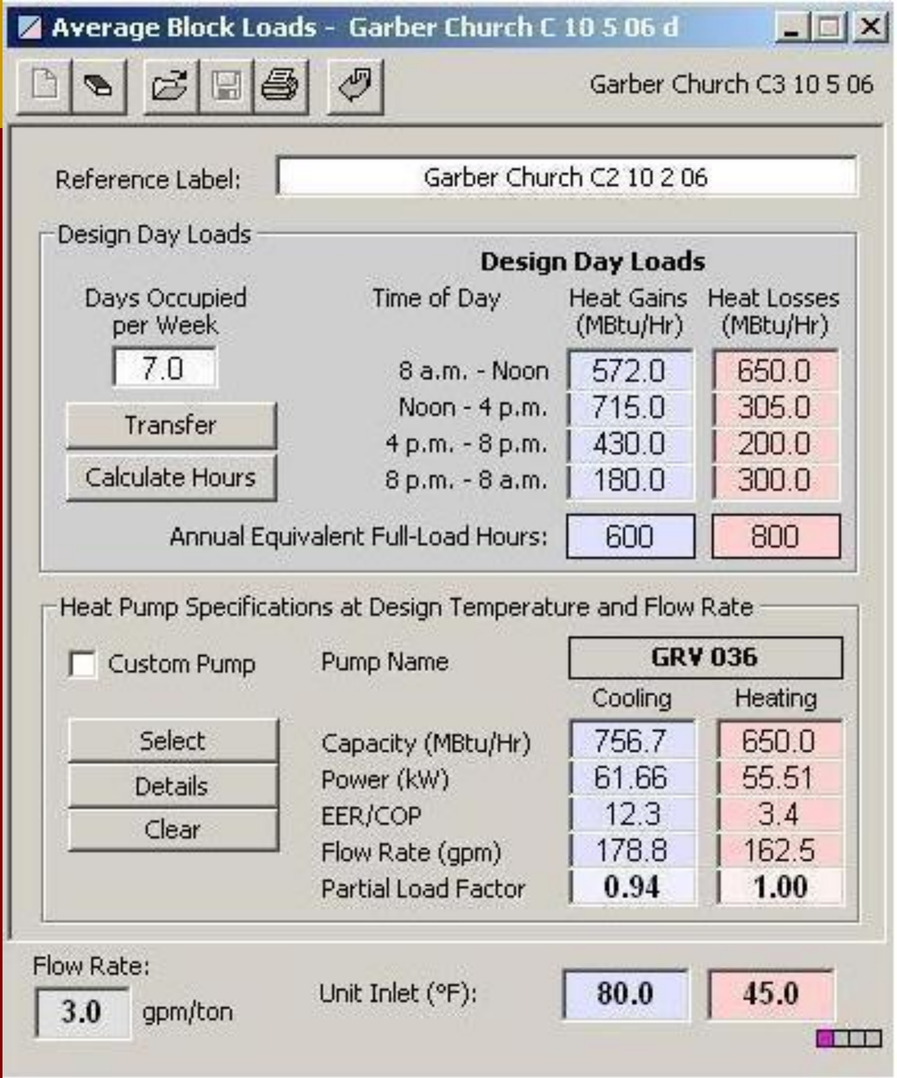
Objectives: Loop Design / Basic Commercial

Commercial Loop Layout



Objectives: Loop Design / Basic Commercial

USE Peak Building Load for Loop Size / AEFLH

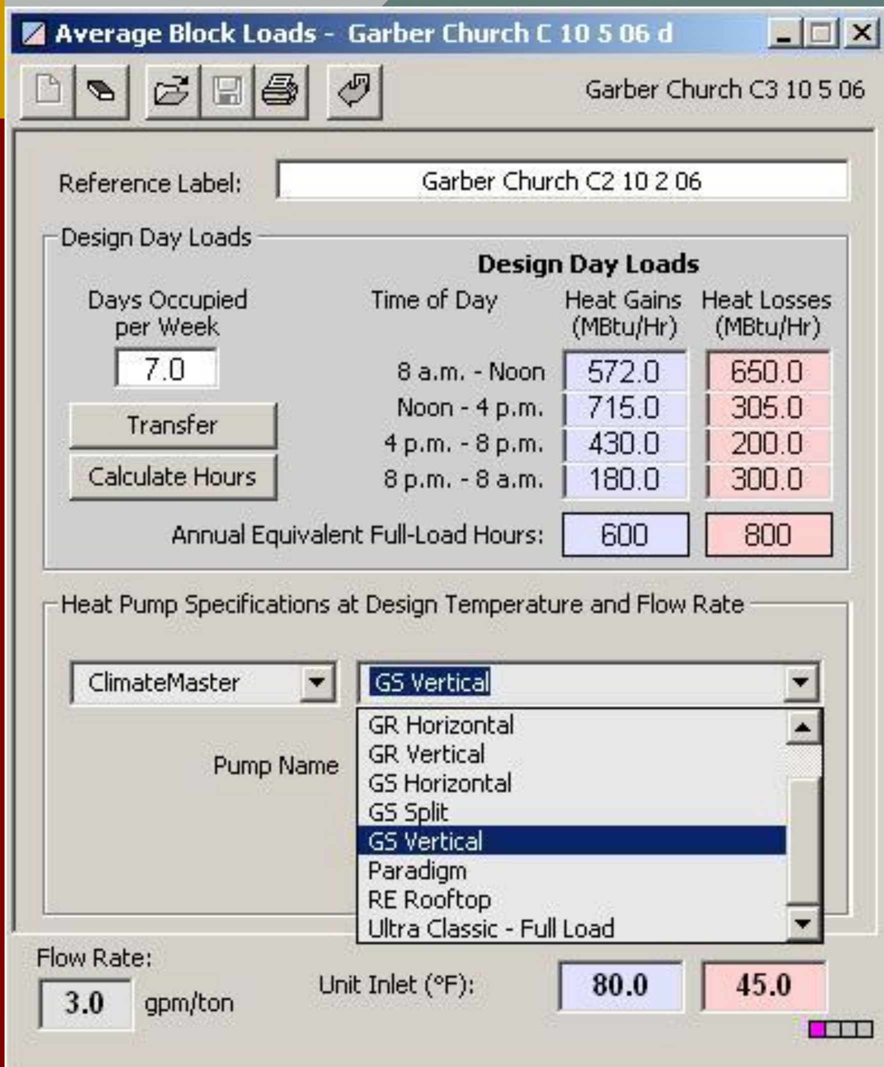


Four Time Periods

Annual Equivalent Full Load Hours

Objectives: Loop Design / Basic Commercial

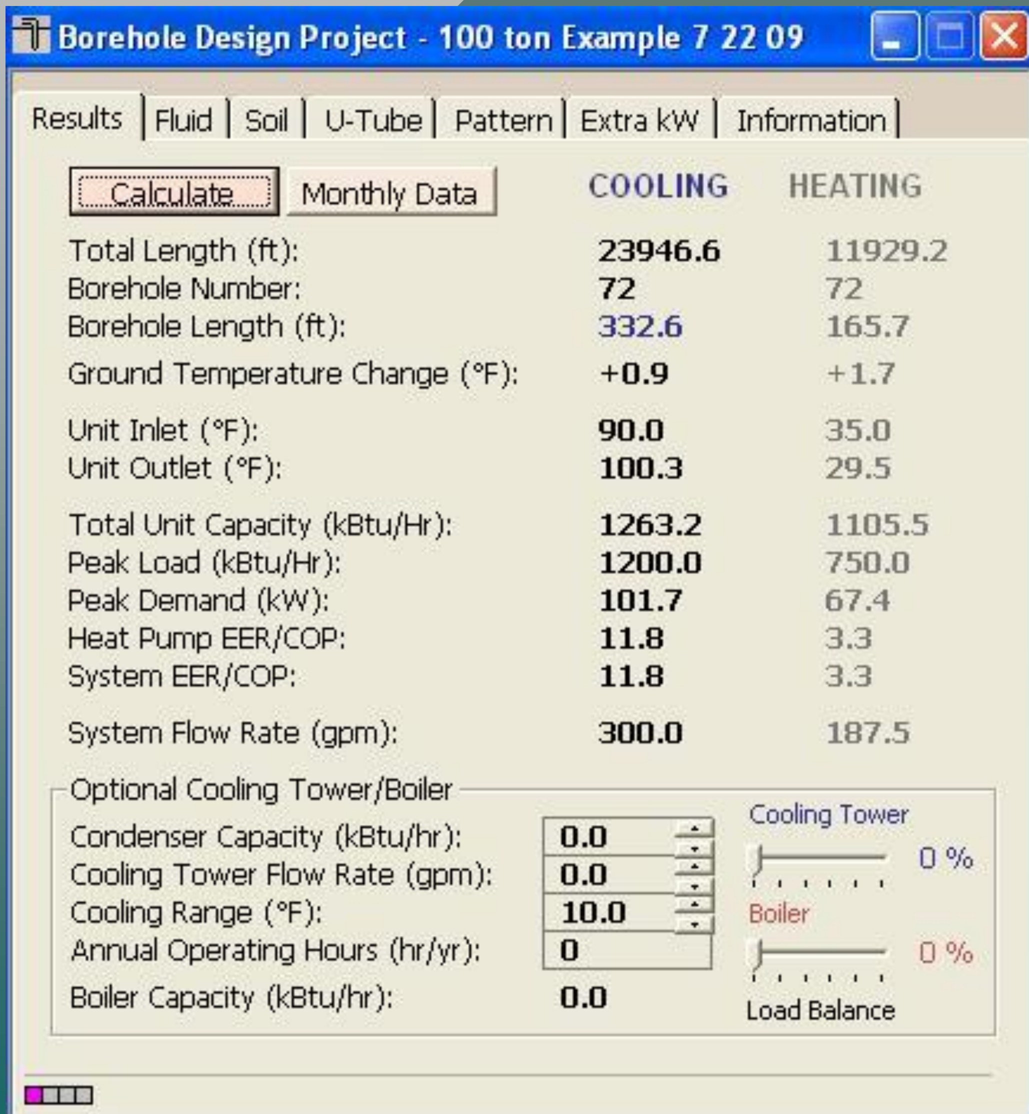
Unit **Sized to Peak Zone Load**



Equipment Selection

Objectives: Loop Design / Vertical

Loop Data



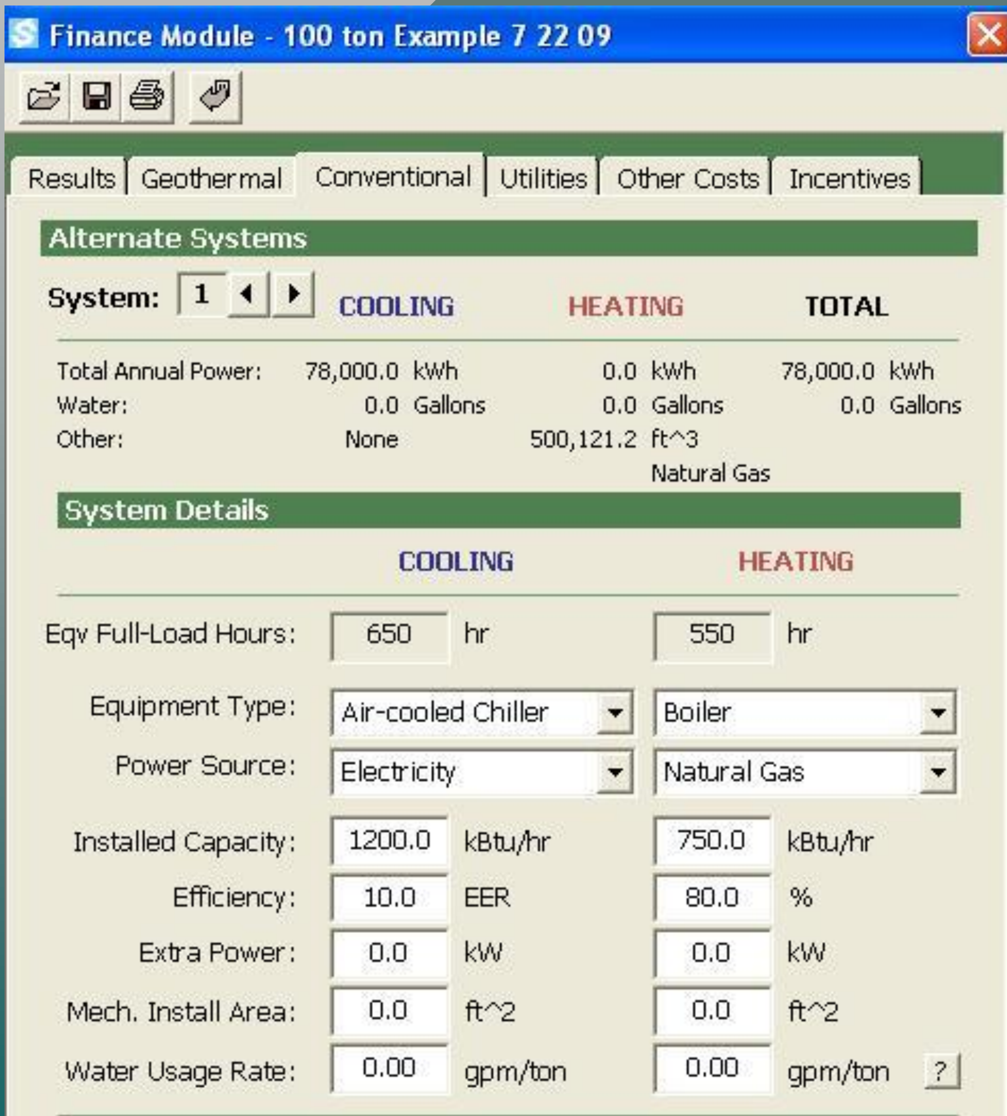
Borehole Depth

System Flow Rate GPM

Optional "Hybrid" Design with Fluid Cooler or Boiler

Objectives: Finance Module

Life Cycle Analysis



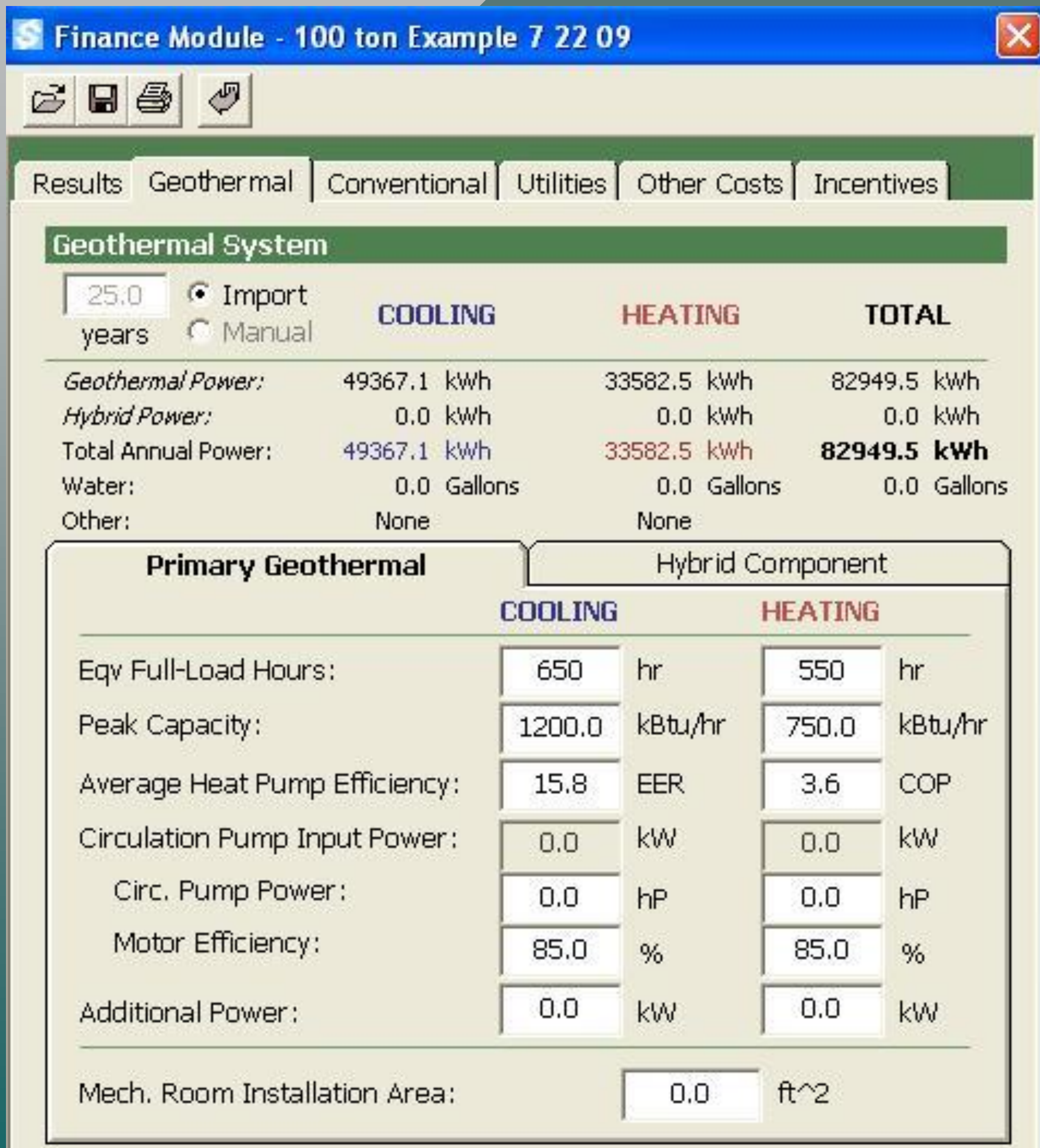
Conventional System Inputs

System Types

System Efficiency

Objectives: Finance Module

Life Cycle Analysis



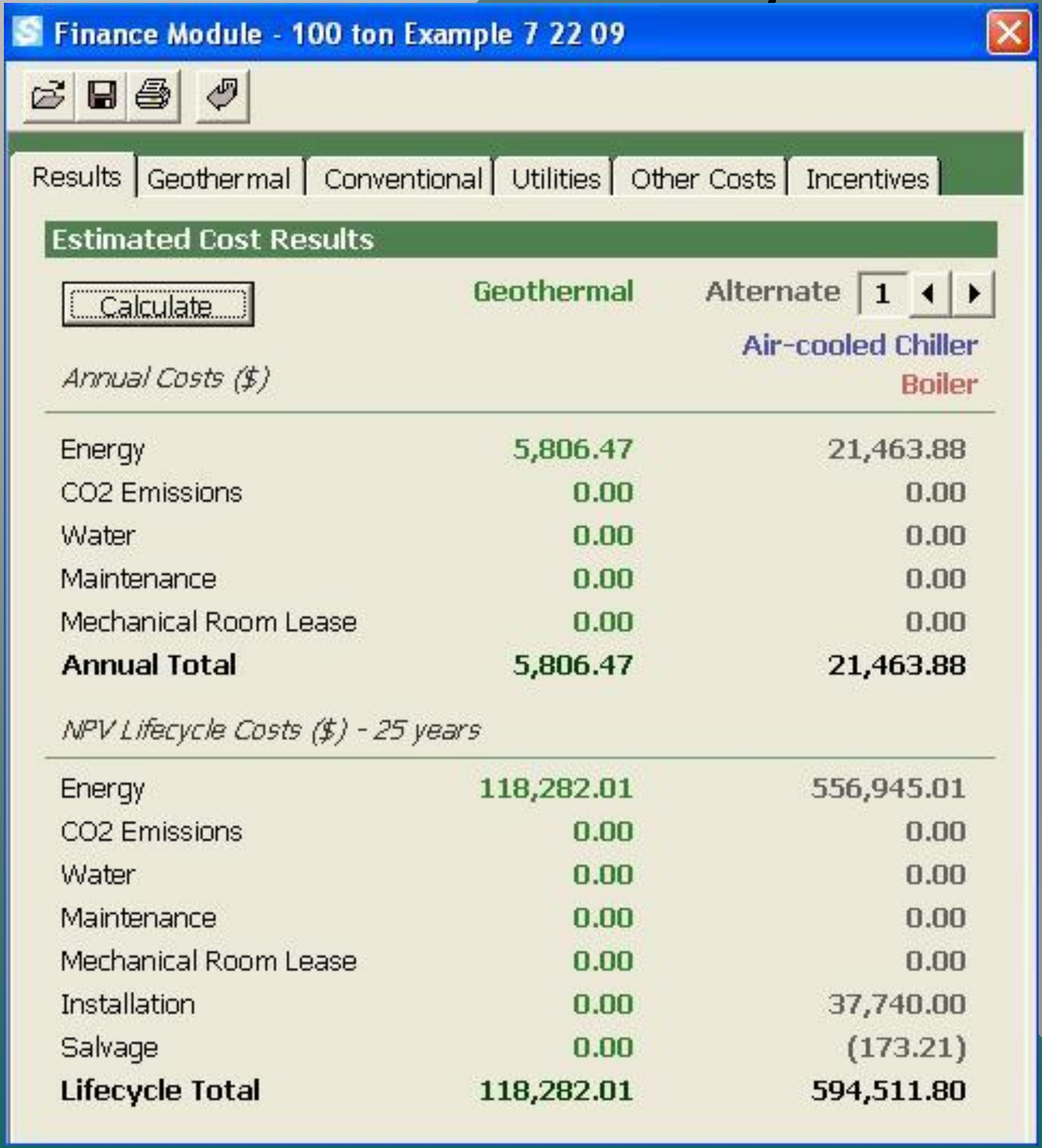
Geothermal System Inputs

System Types

System Efficiency

Objectives: Finance Module

Life Cycle Analysis



Finance Module - 100 ton Example 7 22 09

Results | Geothermal | Conventional | Utilities | Other Costs | Incentives

Estimated Cost Results

Calculate

Annual Costs ($)	Geothermal	Alternate 1: Air-cooled Chiller, Boiler
Energy	5,806.47	21,463.88
CO2 Emissions	0.00	0.00
Water	0.00	0.00
Maintenance	0.00	0.00
Mechanical Room Lease	0.00	0.00
Annual Total	**5,806.47**	**21,463.88**

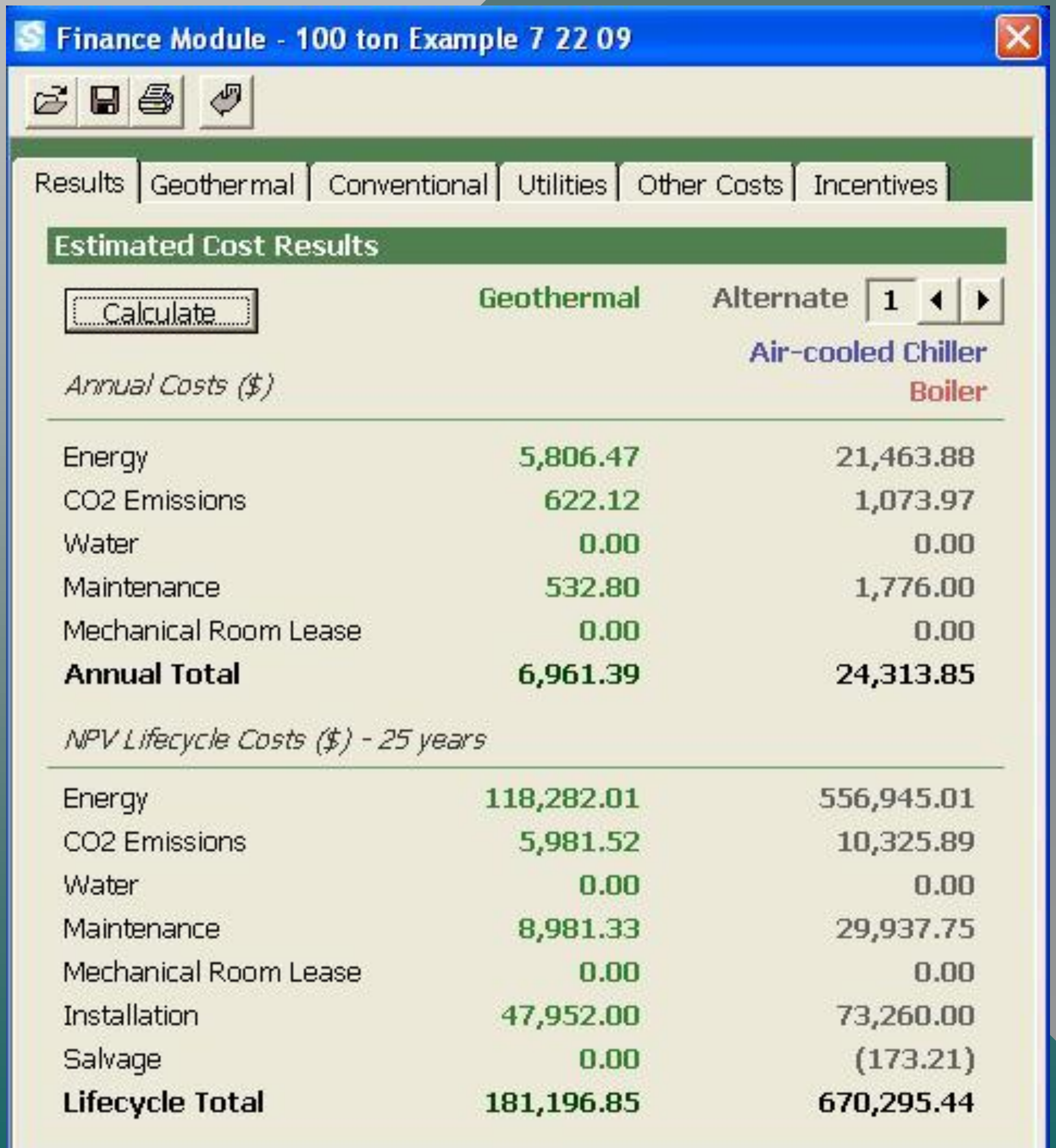
NPV Lifecycle Costs ($) - 25 years	Geothermal	Alternate 1: Air-cooled Chiller, Boiler
Energy	118,282.01	556,945.01
CO2 Emissions	0.00	0.00
Water	0.00	0.00
Maintenance	0.00	0.00
Mechanical Room Lease	0.00	0.00
Installation	0.00	37,740.00
Salvage	0.00	(173.21)
Lifecycle Total	**118,282.01**	**594,511.80**

Annual Energy Savings

25 YR Total Example

Objectives: Finance Module

Life Cycle Analysis



Finance Module - 100 ton Example 7 22 09

Results | Geothermal | Conventional | Utilities | Other Costs | Incentives

Estimated Cost Results

Calculate

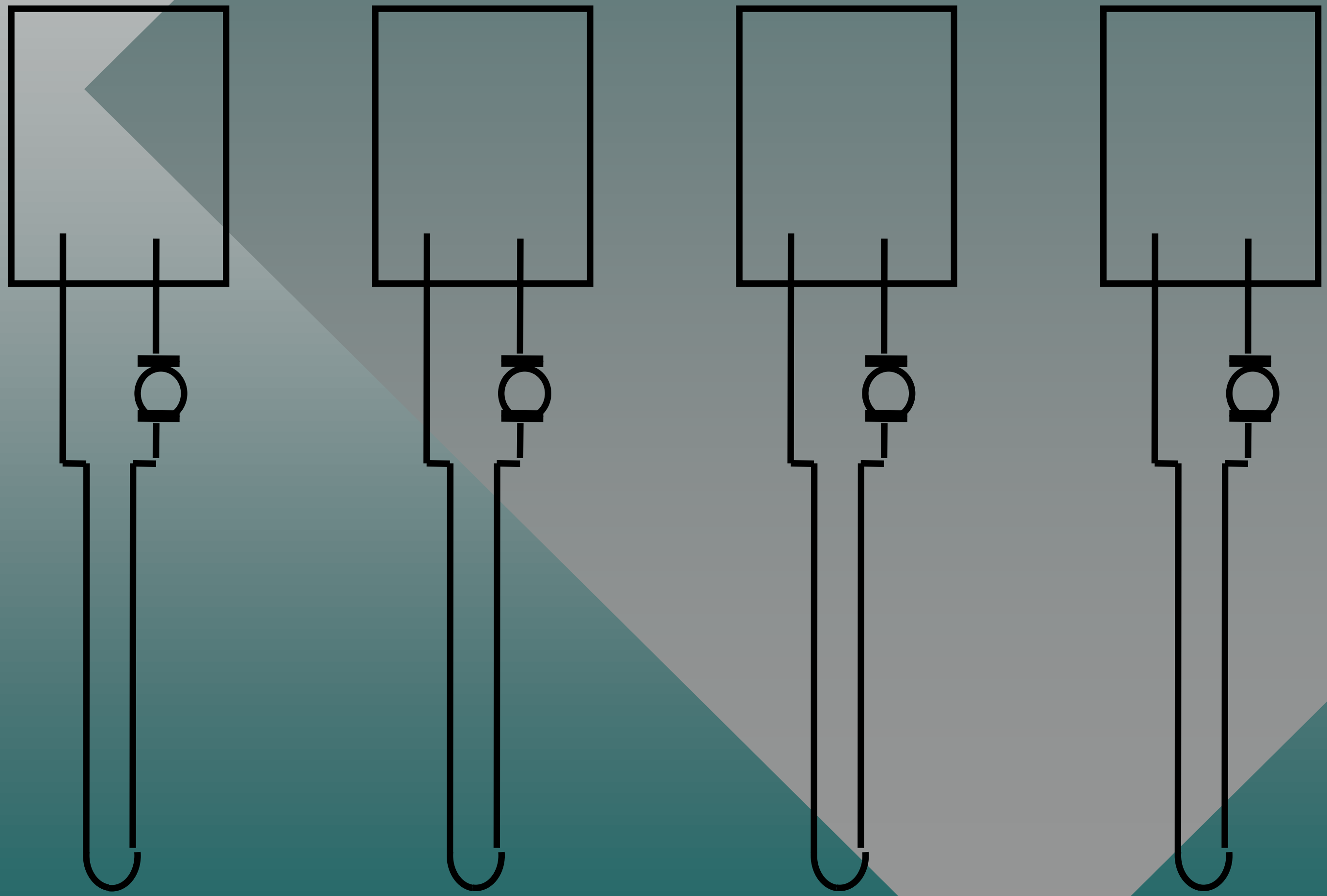
Annual Costs ($)	Geothermal	Alternate 1: Air-cooled Chiller / Boiler
Energy	5,806.47	21,463.88
CO2 Emissions	622.12	1,073.97
Water	0.00	0.00
Maintenance	532.80	1,776.00
Mechanical Room Lease	0.00	0.00
Annual Total	**6,961.39**	**24,313.85**

NPV Lifecycle Costs ($) - 25 years	Geothermal	Alternate 1: Air-cooled Chiller / Boiler
Energy	118,282.01	556,945.01
CO2 Emissions	5,981.52	10,325.89
Water	0.00	0.00
Maintenance	8,981.33	29,937.75
Mechanical Room Lease	0.00	0.00
Installation	47,952.00	73,260.00
Salvage	0.00	(173.21)
Lifecycle Total	**181,196.85**	**670,295.44**

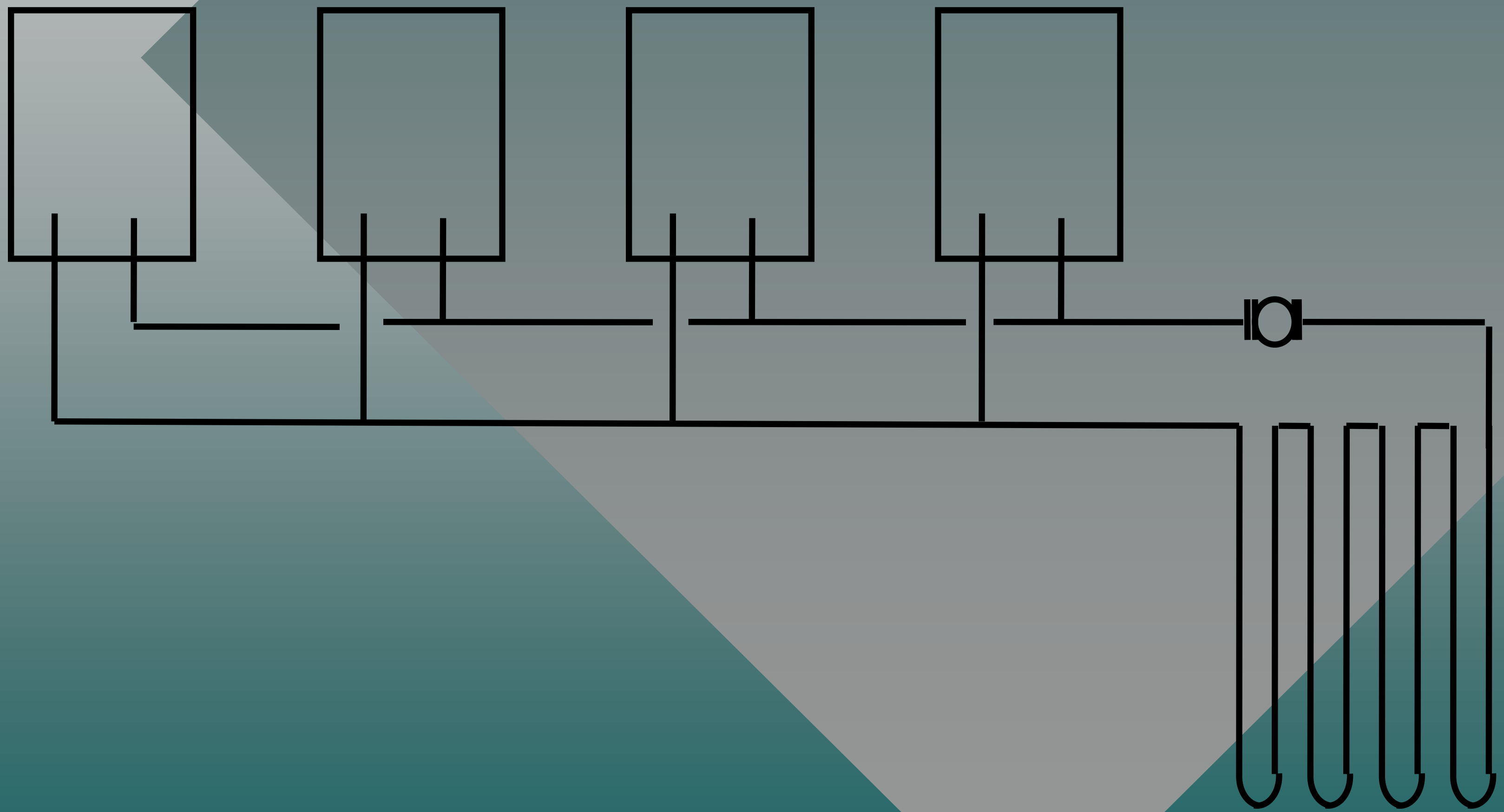
Full Life Cycle Cost Data

25 YR Total Example

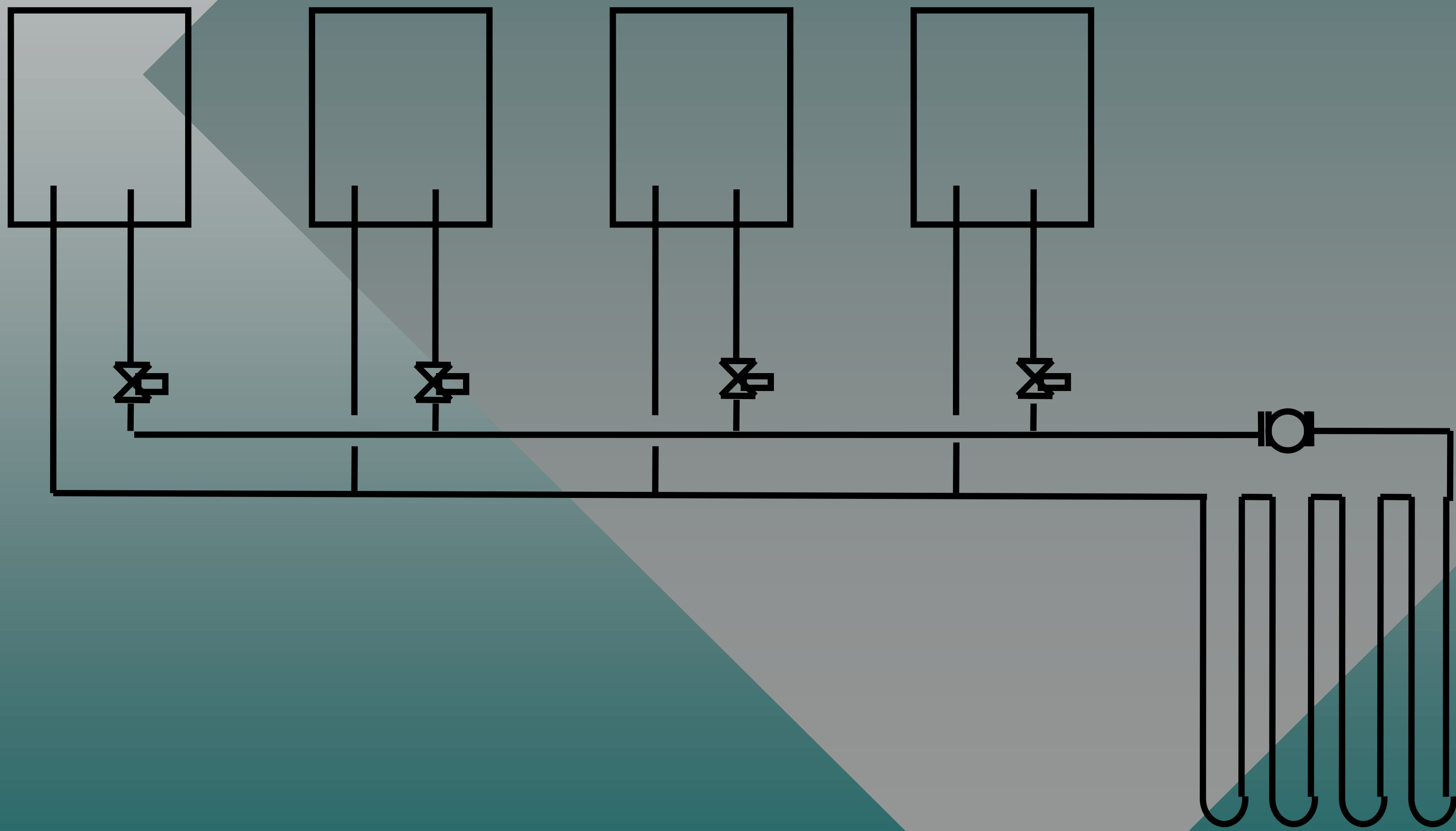
Independent Systems



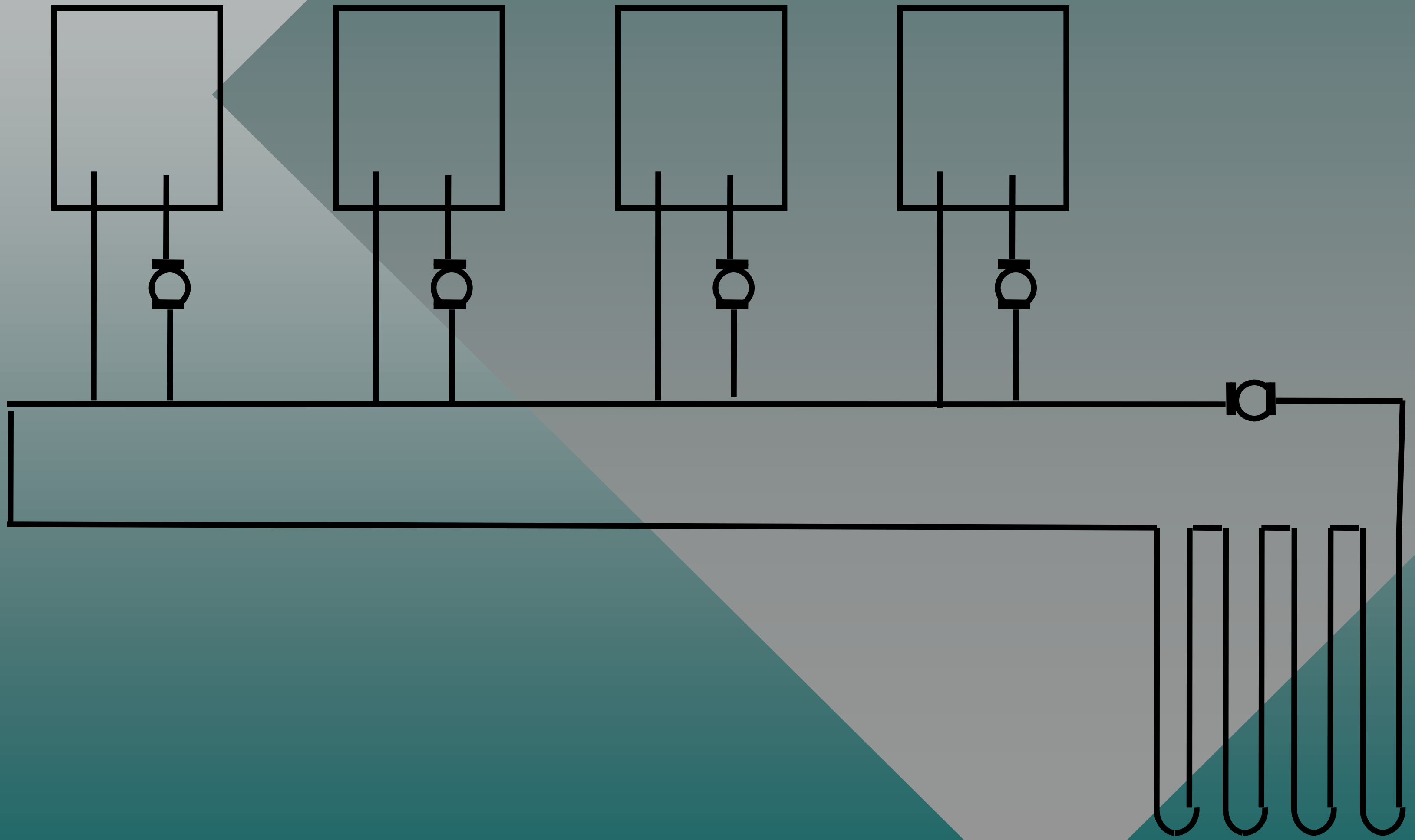
Central 2-Pipe Constant-Speed



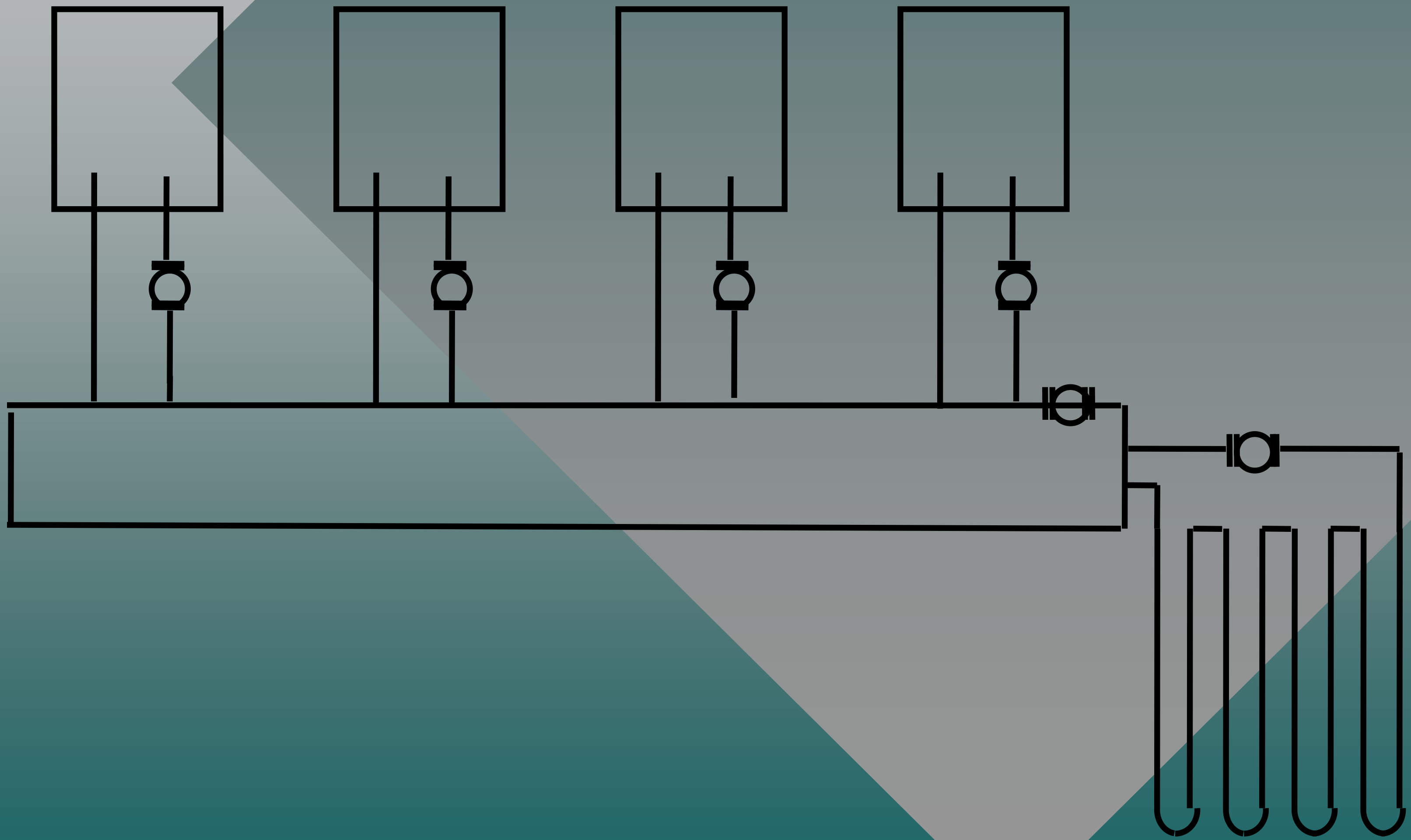
Central 2-Pipe Variable-Speed



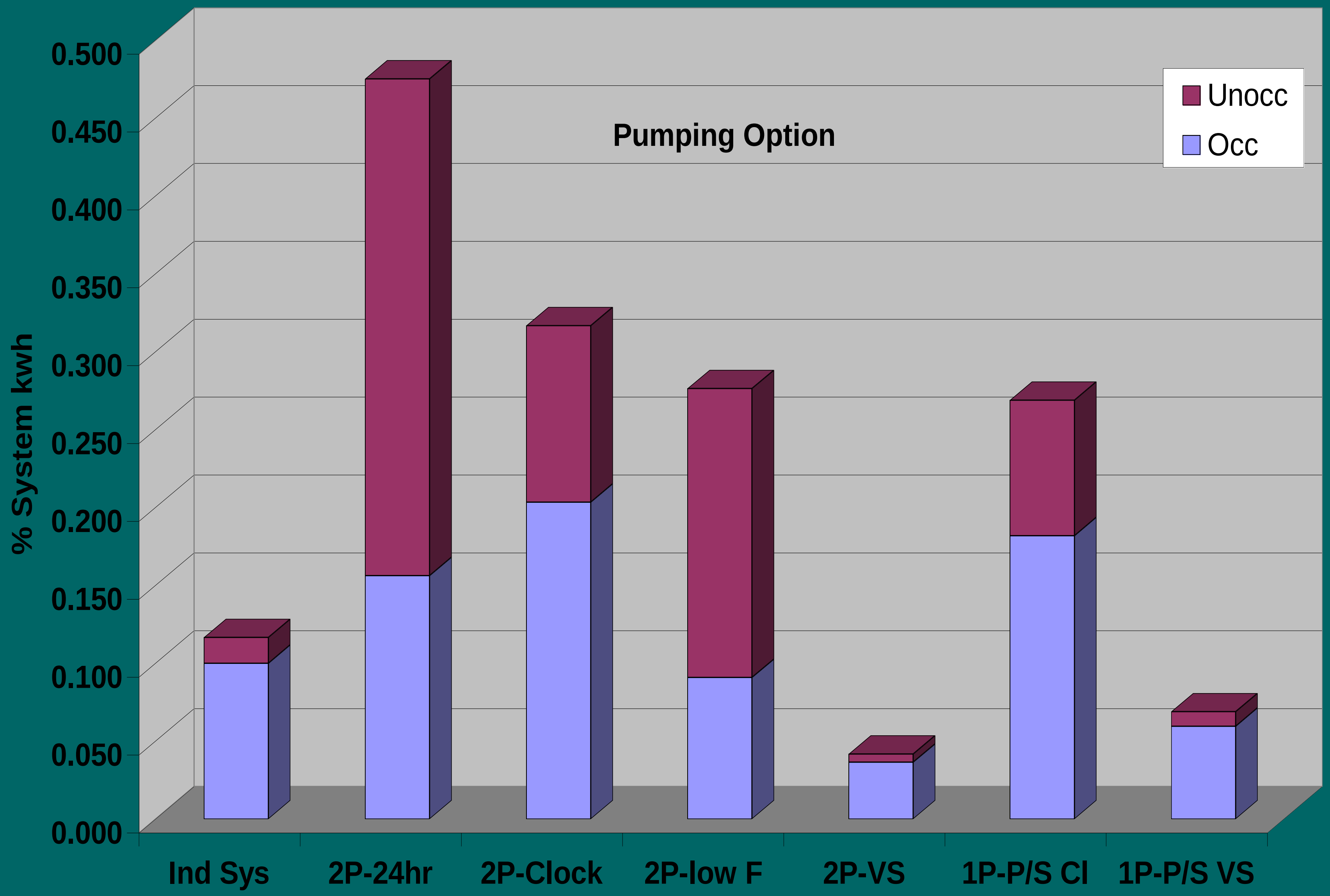
Central 1-Pipe Primary/Secondary



Central 1-Pipe Primary/Secondary



Example: Pumping Energy Comparison



Sizing Procedures

Calculate Building / Zone Heating / Cooling Loads

Select Geothermal Heat Pump/s for Building / Zones

Design Ground Loop System

Run Operating Costs Comparison Using a Software Program

Verify Dehumidification in Cooling Mode

Check Effects on Ground Loop System by Unit Size

Questions?

MNGHPA
Minnesota Geothermal Heat Pump Association

Thanks for Your Time!