

Geothermal Heat Pumps

GHP-101

California Energy Commission

DOCKETED

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What Makes it a Geothermal Heat Pump System?

- ❑ Extended-Range Water-Source Heat Pump
- ❑ Ground Heat Exchanger
- ❑ Circulation Pump
- ❑ Distribution

Geothermal Heat Pump Equipment



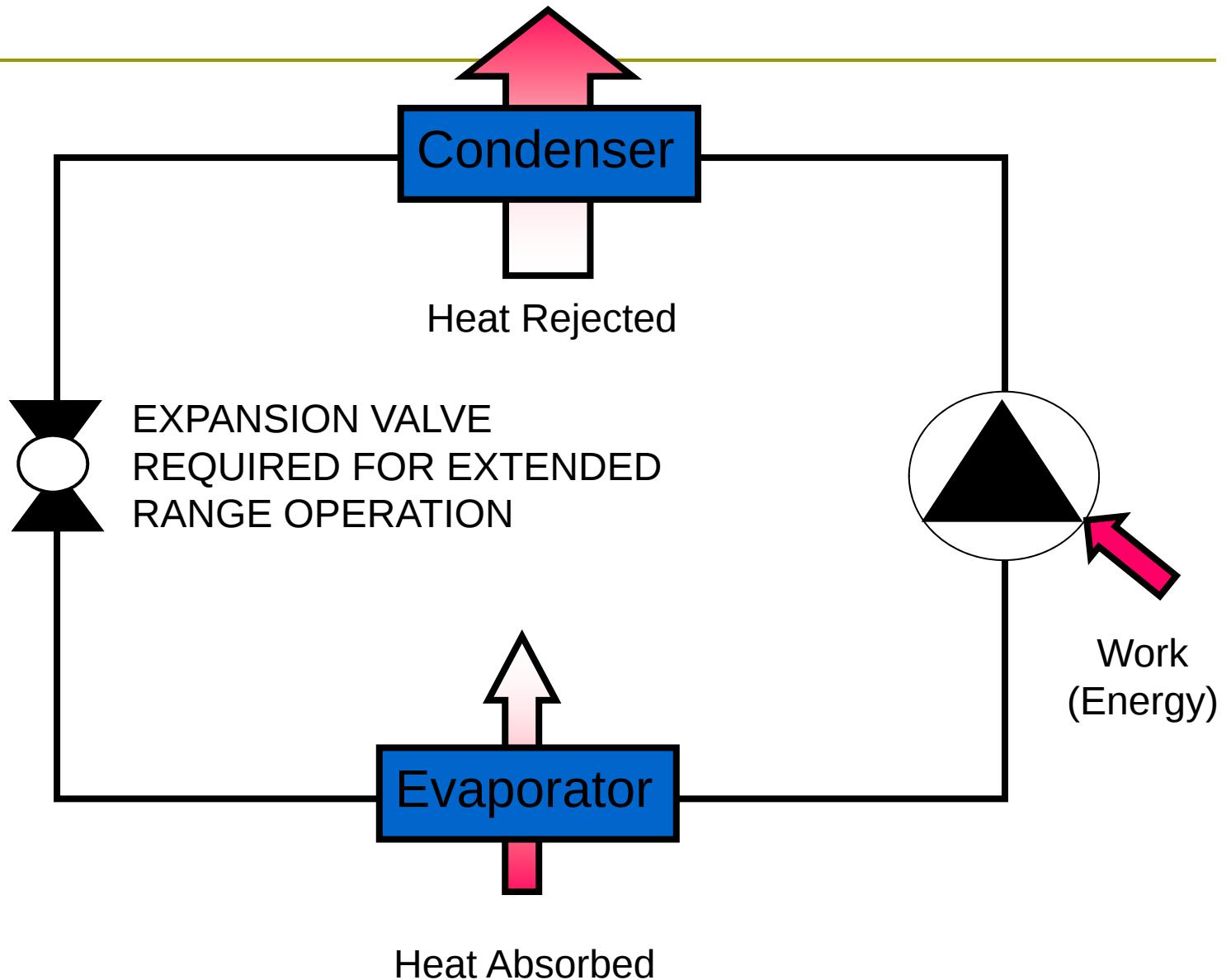
Photo courtesy of Water Furnace



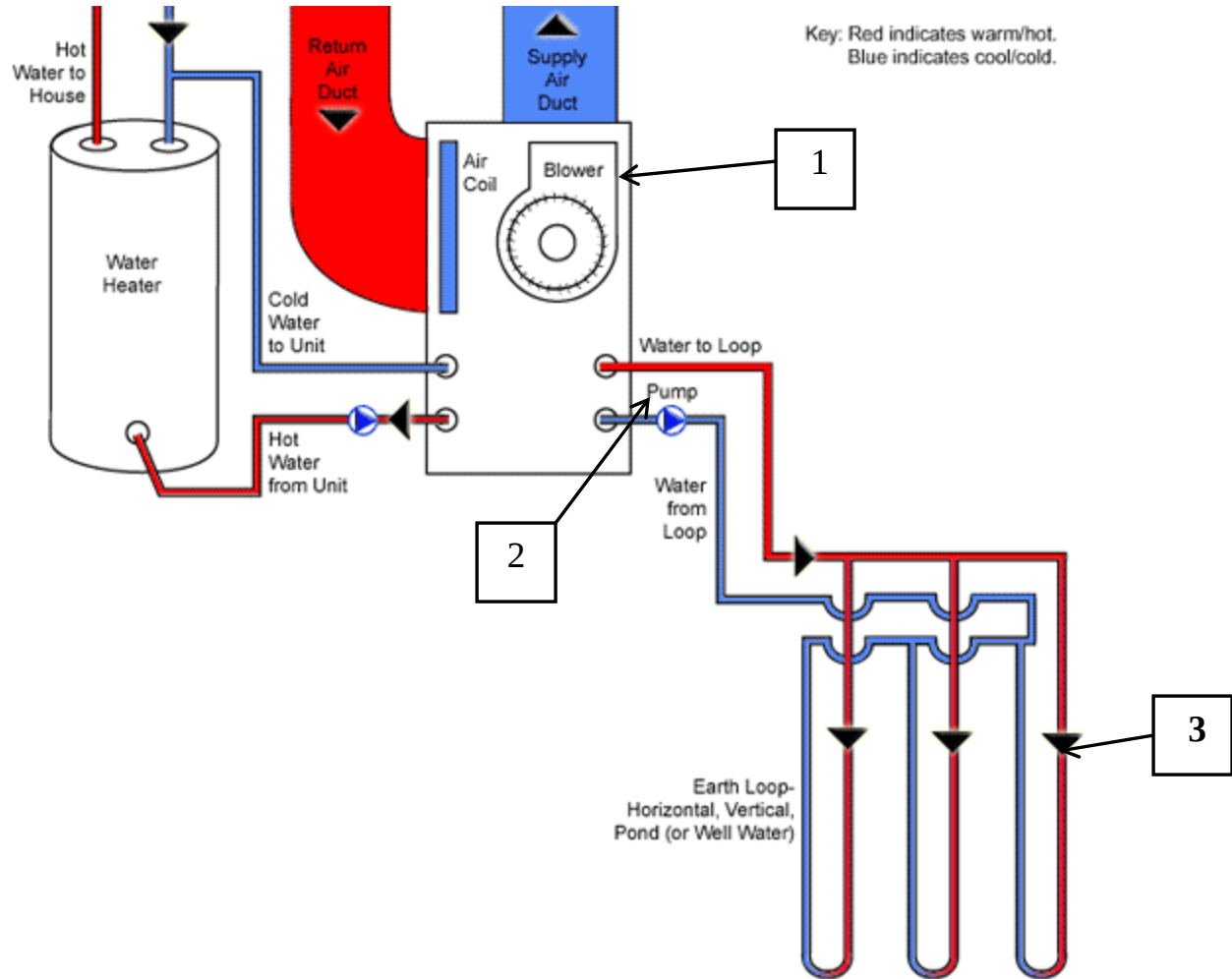
Geothermal Heat Pumps:

- ❑ Are all-electric
- ❑ Do not require “Geothermal hot water
- ❑ Can be an open or closed loop system
- ❑ Can be *hybridized*

How a Heat Pump Works



Basic GHP System





How do GHPs differ from conventional HVAC systems

□ Coefficient of Performance (COP)

Q/W_c = the heat delivered (or removed) divided by the work of the compressor

□ Energy Efficiency Rating (EER)

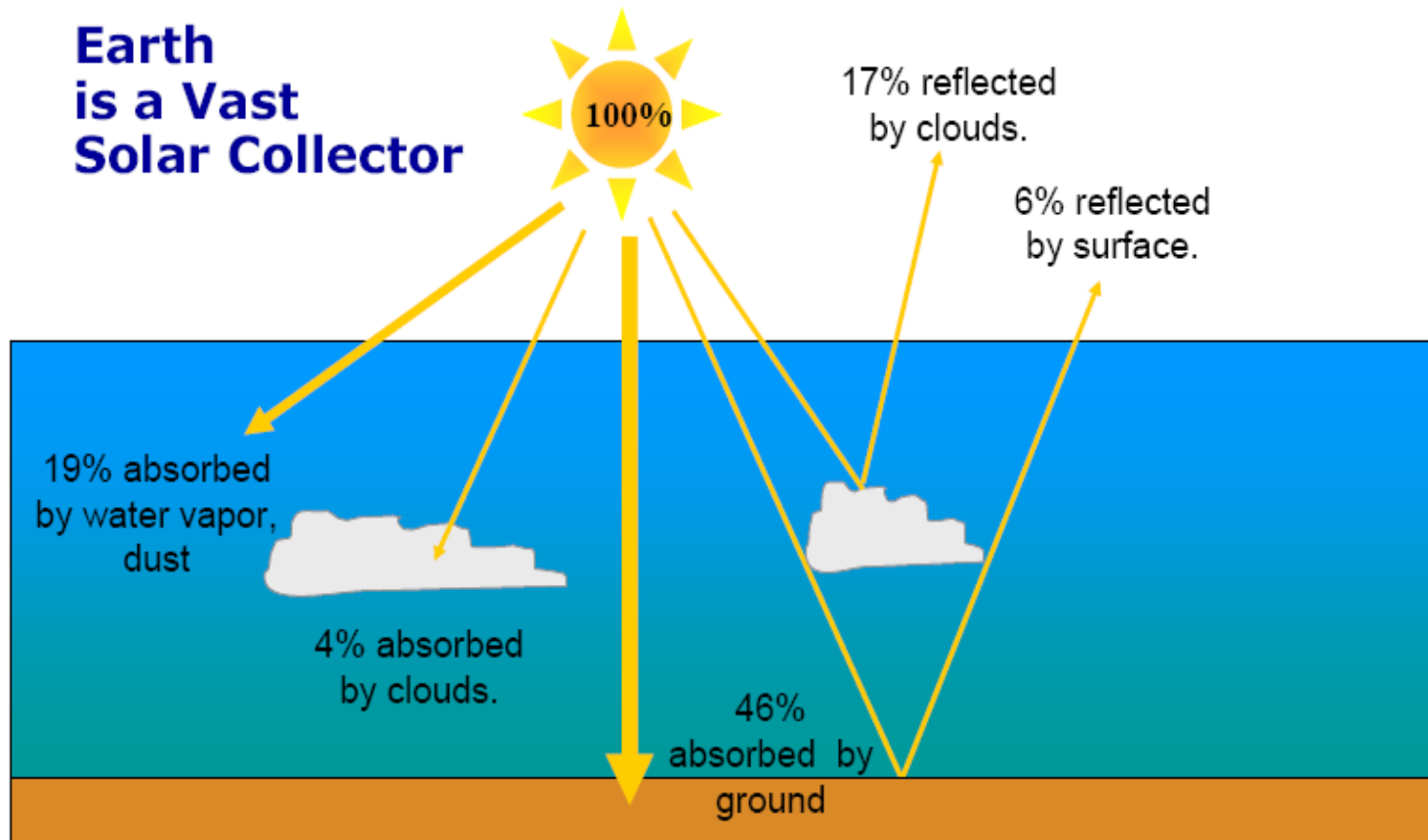
W_c/Q = energy consumption (kW) divided by the heat removed (tons)



GHP System Components

- ❑ Extended-Range Water-Source Heat Pump
- ❑ Ground Heat Exchanger
- ❑ Circulation Pump
- ❑ Distribution

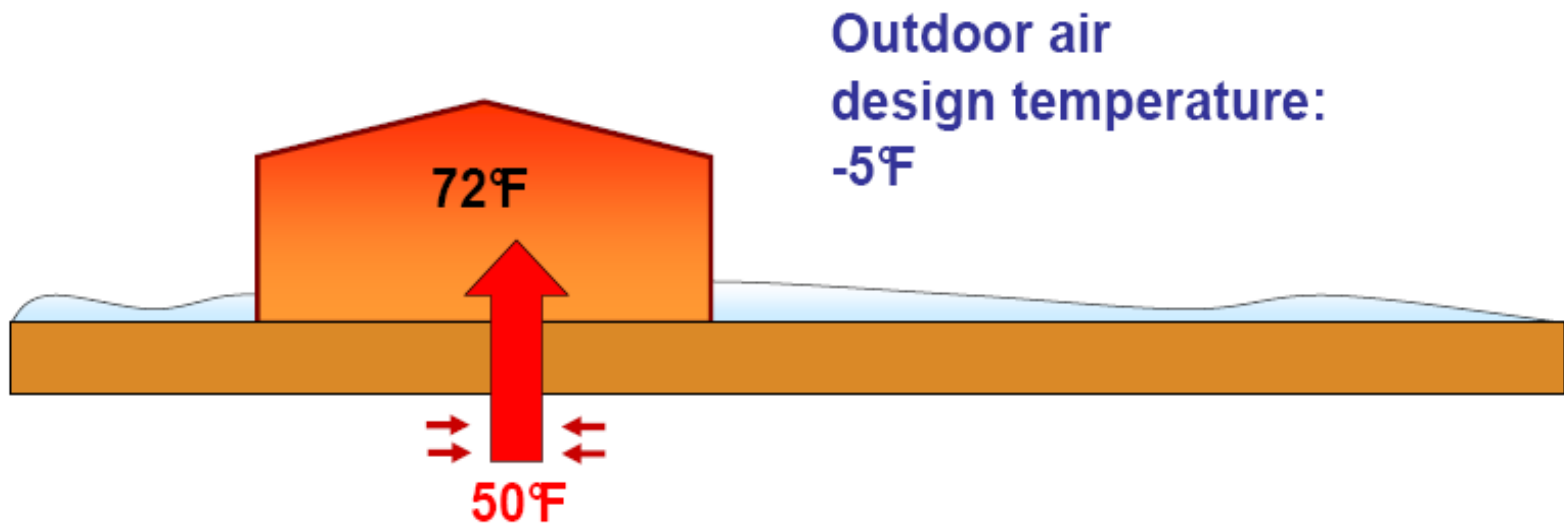
The Loop - The Renewable Connection



Solar energy maintains a nearly constant temperature throughout the year just below ground

Diagram courtesy of FHP Bosch

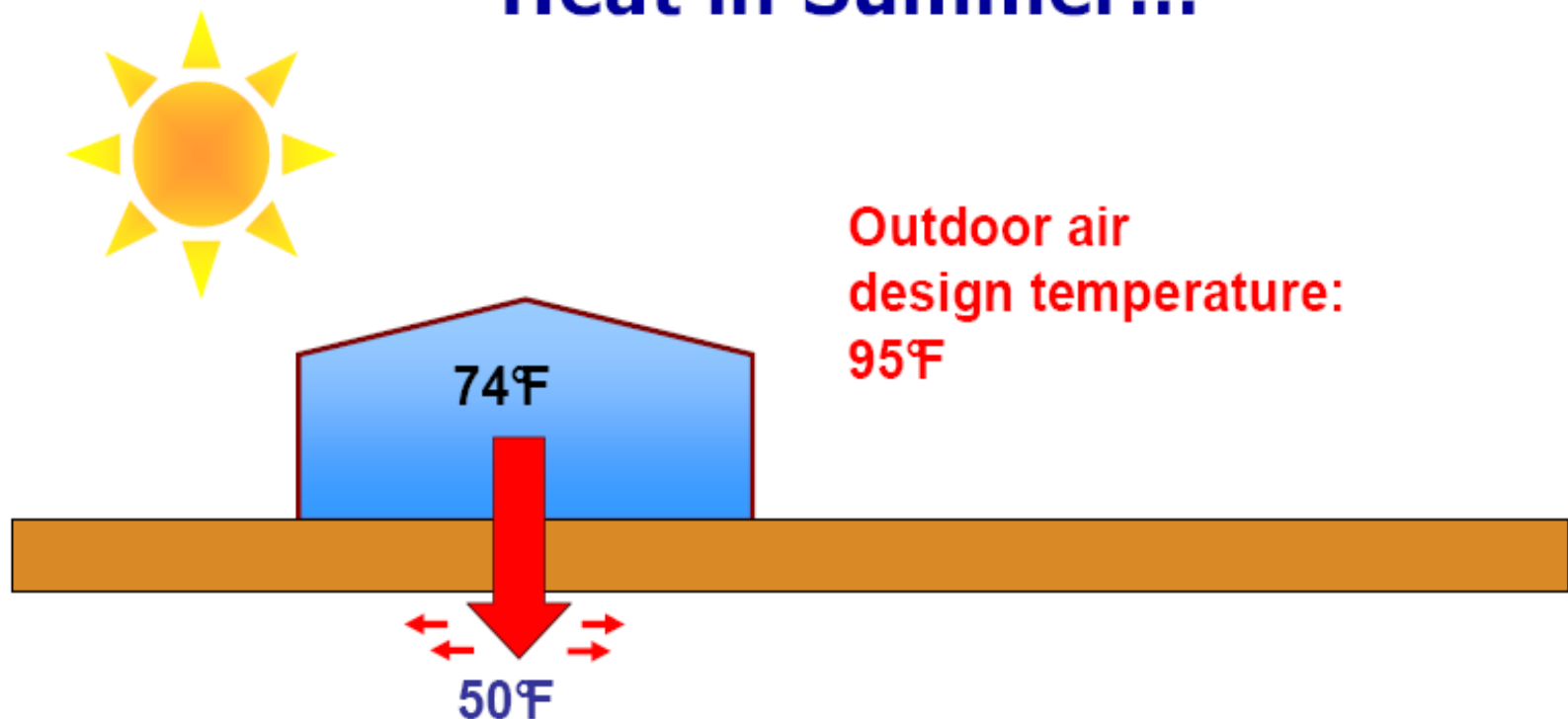
The Earth is a Source of Heat in Winter...



Geothermal heat pumps transfer underground heat into buildings to provide heating

Diagram courtesy of FHP Bosch

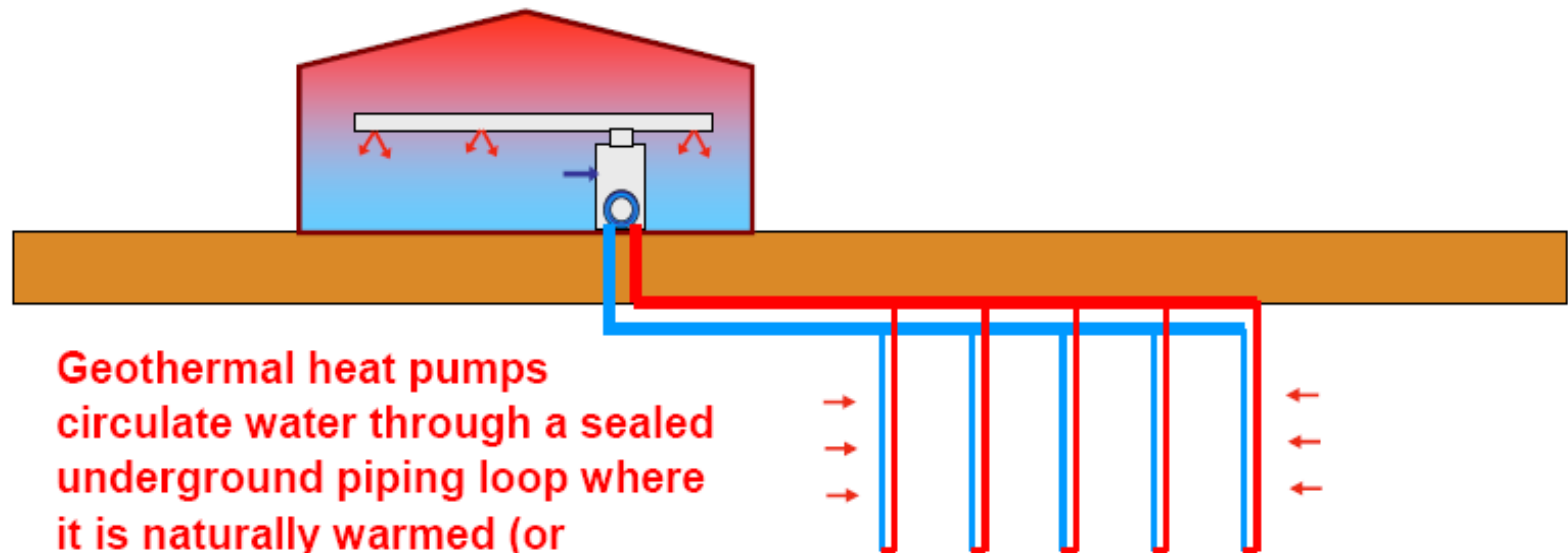
...and an Efficient Place to Reject Heat in Summer...



Geothermal heat pumps transfer heat from buildings into the ground to provide cooling

Diagram courtesy of FHP Bosch

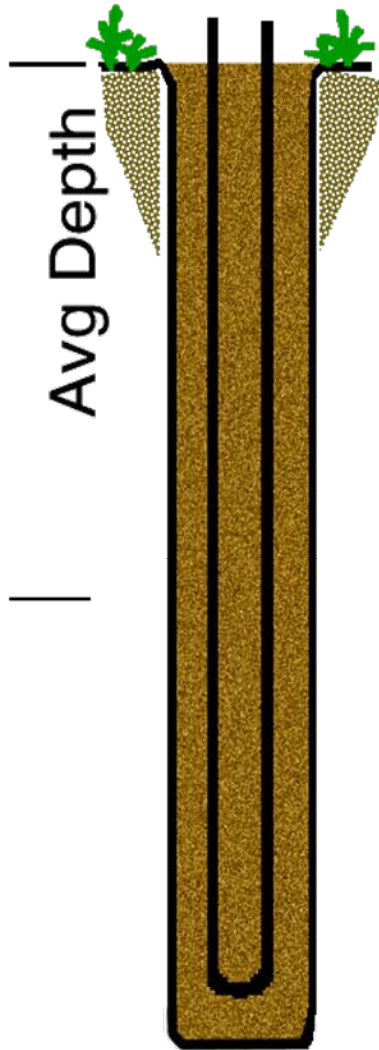
...using Heat Pump Technology



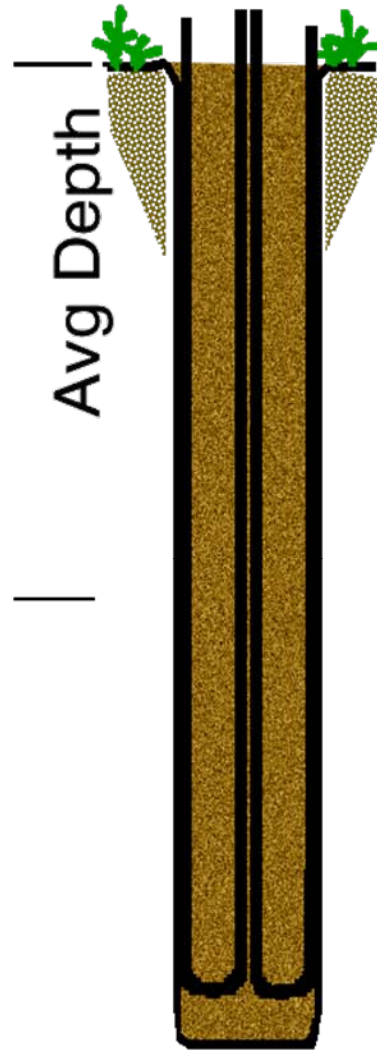
Geothermal heat pumps circulate water through a sealed underground piping loop where it is naturally warmed (or cooled) by the Earth

Diagram courtesy of FHP Bosch

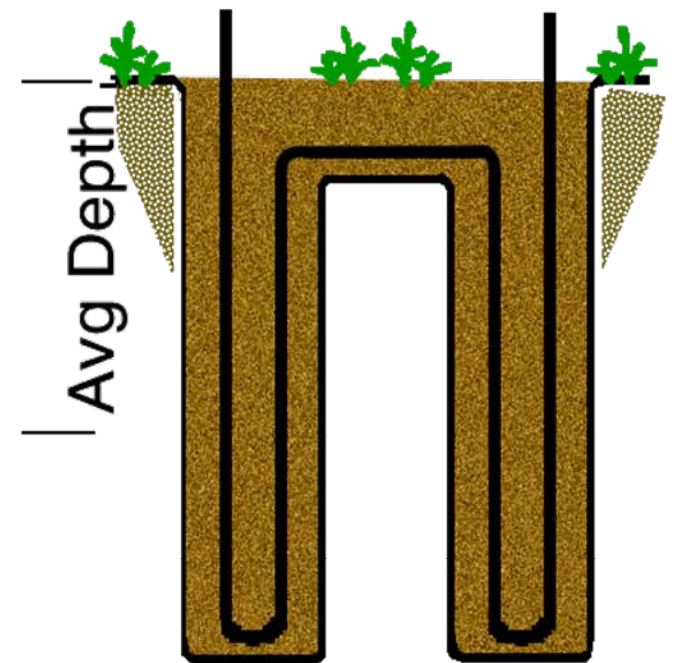
Vertical Loop Examples



One Pair



Two Pair



Series/Parallel One Pair

Drilling at an Alamo Residence



Fusion-welding pipe in the trench



Trenching at Alamo Residence



High-Density Polyethylene Pipe



Backfilling the Headers (Mains)



Marin Community College: System Flush



How Do We Design ‘The Loop’

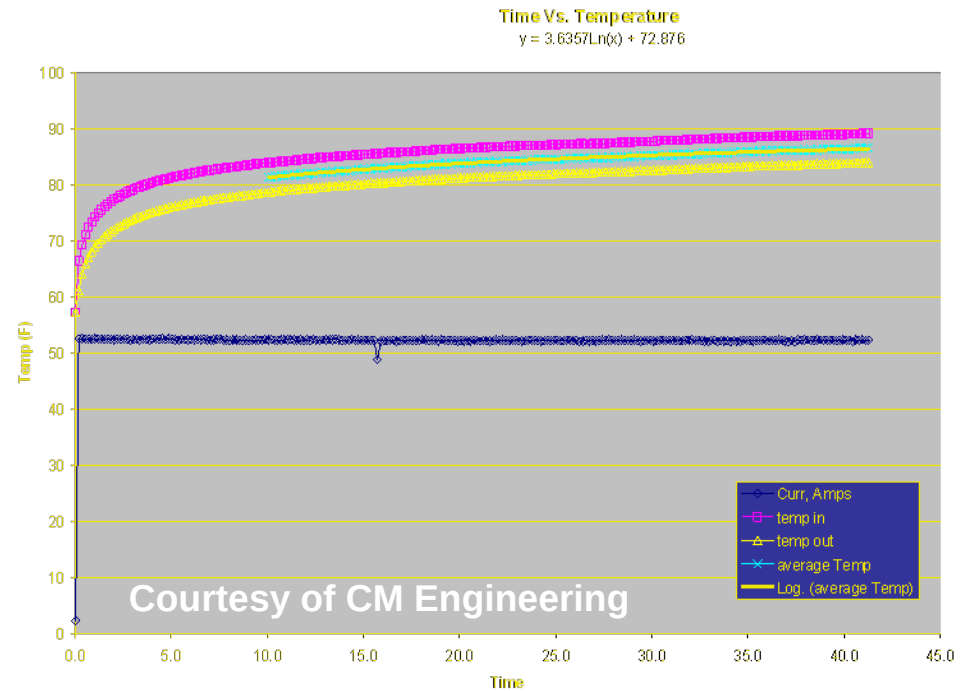
- ❑ Thermal Conductivity
- ❑ Deep Earth Temp
- ❑ Thermal Diffusivity



Where is this information found?

- Well Logs
- Experience
- Thermal Conductivity Test

Thermal Conductivity Testing



Time Period	Slope	Average He (Btu/hr-ft)	at Input (W/ft)	Thermal Conductivity (Btu/hr-ft-°F)
10—44	4.3		21.25	1.34



Actual Well Log Example

Drillers Log

Topsoil	0-3
Brown Sandy Clay	3-27
Gray Sticky Clay with Sand	27-62
Coarse Gray Sand, Gravel, and Cobbles-Water Bearing	62-89
Gray/Brown Limestone	89-265
Gray Dolomite	265-368
Blue-Gray Dolomite	368-375
Gray/Light Gray Sandstone	375-426
Tan Sandstone	426-500

What else do we need to know?

- ❑ HDPE Pipe Size
- ❑ Grout Properties
- ❑ Pipe Spacing
- ❑ Pipe Depth
- ❑ Inlet design temperatures to the
Extended Range Water Source HPs



Surface Water (Pond) Loops





HDPE Coils or...



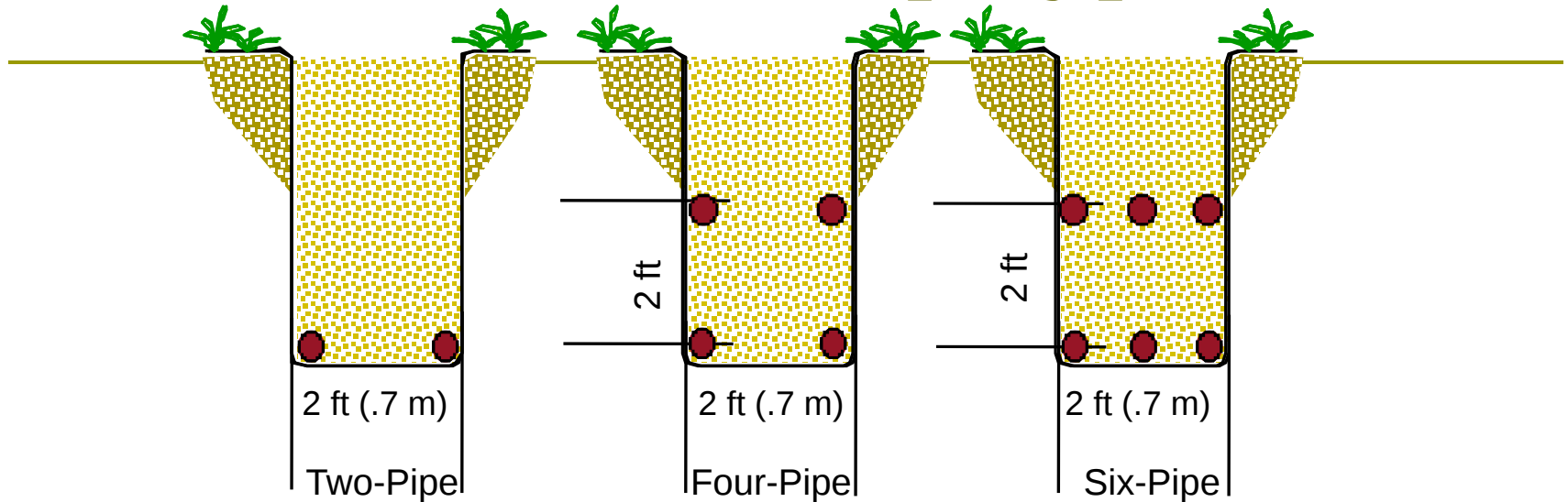


a Closed- Loop Plate Heat Exchanger?

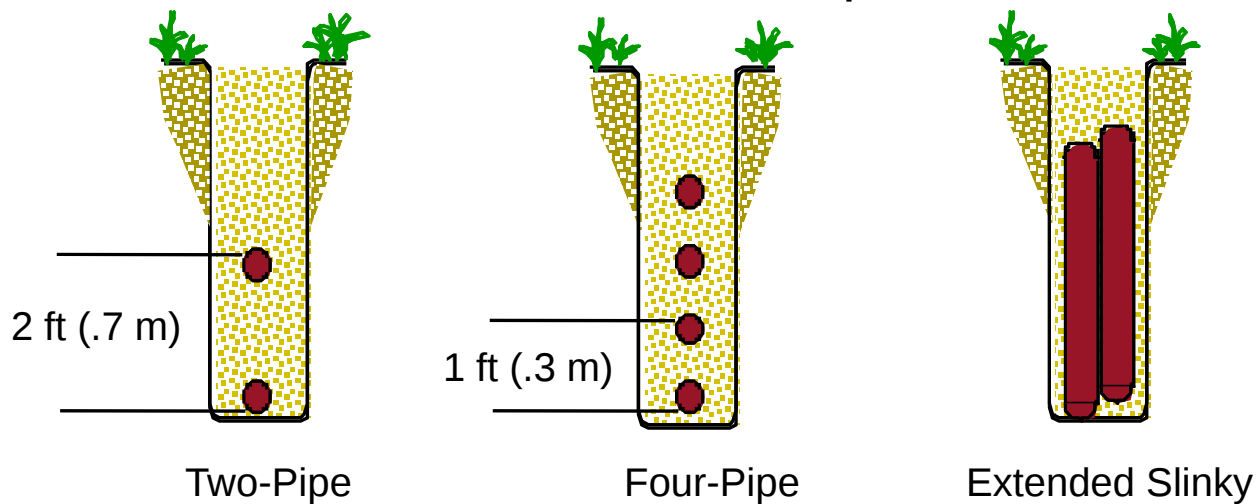




Horizontal Loop Types



Back-Hoe Loops



Slinky Loop



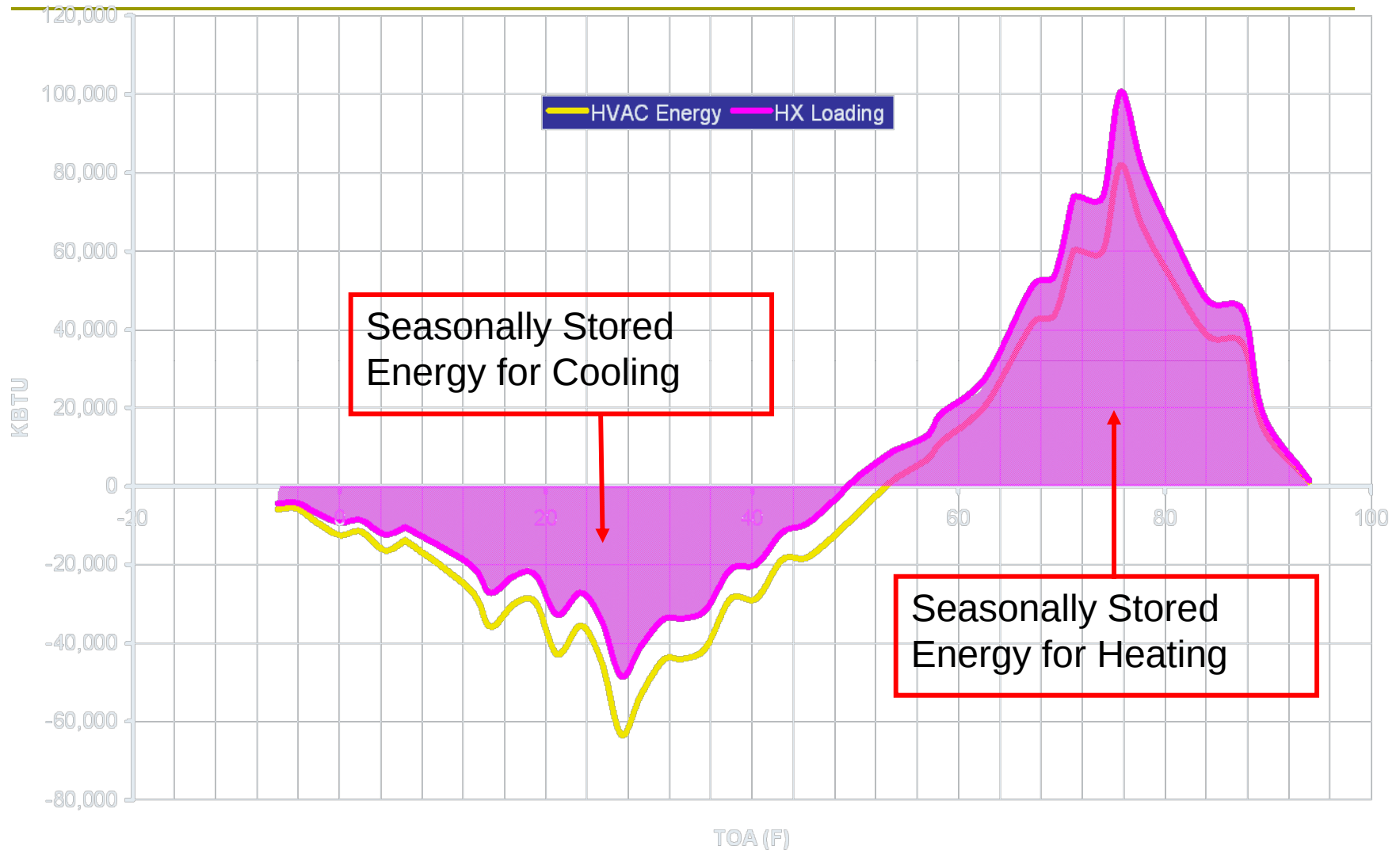
Horizontal or Directional Drilling



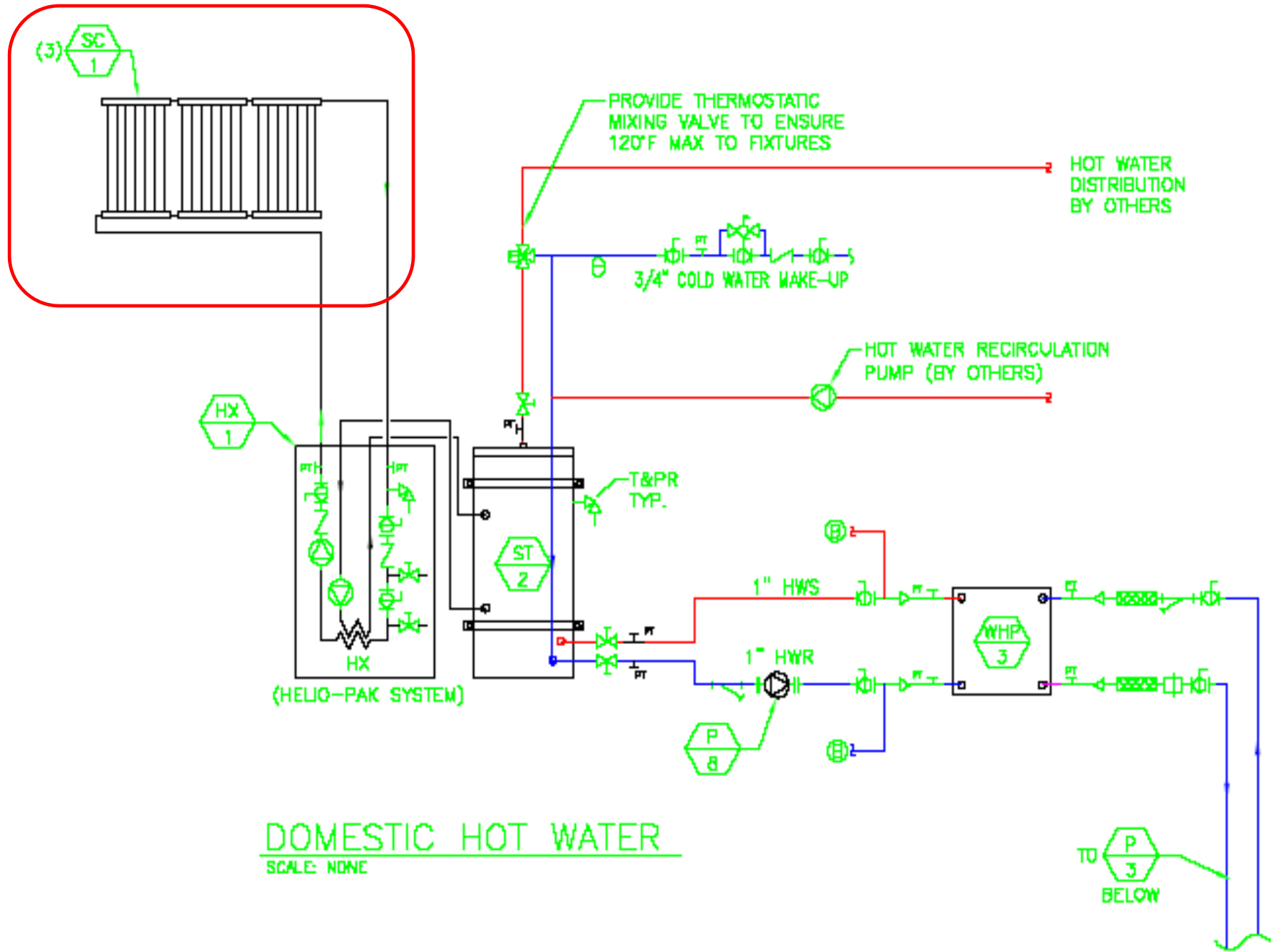
Horizontal Drilling - continued

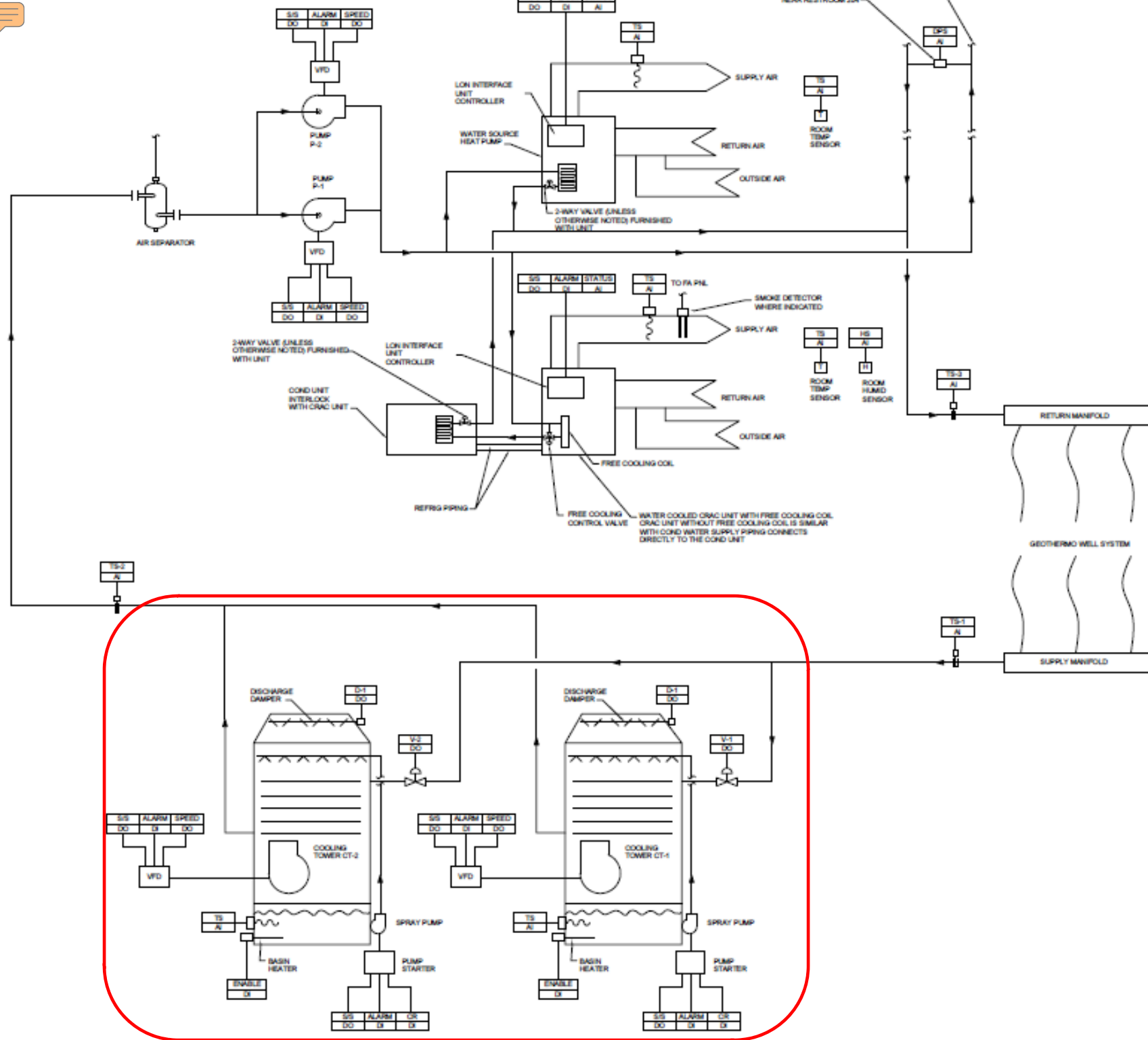


Seasonal Energy Usage



Hybrid GHP Systems





Life Cycle Cost and Equipment Lifetime

Owning and Operating Costs

Table 4 Comparison of Service Life Estimates

Equipment Item	Median Service Life, Years		Equipment Item	Median Service Life, Years		Equipment Item	Median Service Life, Years	
	Abramson et al. (2005)	Akalin (1978)		Abramson et al. (2005)	Akalin (1978)		Abramson et al. (2005)	Akalin (1978)
Air Conditioners			Air Terminals			Condensers		
Window unit	N/A*	10	Diffusers, grilles, and registers	N/A*	27	Air-cooled	N/A	20
Residential single or split package	N/A*	15	Induction and fan-coil units	N/A*	20	Evaporative	N/A*	20
Commercial through-the-wall	N/A*	15	VAV and double-duct boxes	N/A*	20	Insulation		
Water-cooled package	>24	15	Air washers	N/A*	17	Molded	N/A*	20
Heat pumps			Ductwork	N/A*	30	Blanket	N/A*	24
Residential air-to-air	N/A*	15 ^b	Dampers	N/A*	20	Pumps		
Commercial air-to-air	N/A*	15	Fans	N/A*		Base-mounted	N/A*	20
Commercial water-to-air	>24	19	Centrifugal	N/A*	25	Pipe-mounted	N/A*	10
Roof-top air conditioners			Axial	N/A*	20	Sump and well	N/A*	10
Single-zone	N/A*	15	Propeller	N/A*	15	Condensate	N/A*	15
Multizone	N/A*	15	Ventilating roof-mounted	N/A*	20	Reciprocating engines	N/A*	20
Boilers, Hot-Water (Steam)			Coils			Steam turbines	N/A*	30
Steel water-tube	>22	24 (30)	DX, water, or steam	N/A*	20	Electric motors	N/A*	18
Steel fire-tube		25 (25)	Electric	N/A*	15	Motor starters	N/A*	17
Cast iron	N/A*	35 (30)	Heat Exchangers			Electric transformers	N/A*	30
Electric	N/A*	15	Shell-and-tube	N/A*	24	Controls		
Burners	N/A*	21	Reciprocating compressors	N/A*	20	Pneumatic	N/A*	20
Furnaces			Packaged Chillers			Electric	N/A*	1
Gas- or oil-fired	N/A*	18	Reciprocating	N/A*	20	Electronic	N/A*	1
Unit heaters			Centrifugal	>25	23	Valve actuators		
Gas or electric	N/A*	13	Absorption	N/A*	23	Hydraulic	N/A*	1
Hot-water or steam	N/A*	20	Cooling Towers			Pneumatic	N/A*	2
Radiant heaters			Galvanized metal	>22	20	Self-contained		1
Electric	N/A*	10	Wood	N/A*	20			
Hot-water or steam	N/A*	25	Ceramic	N/A*	34			

*N/A (not available) for these categories may be outdated and not statistically relevant. Use these data with caution.

Long-Term Commercial GSHP Performance

Part 7: Achieving Quality

By Steve Kavanaugh, Ph.D., Fellow ASHRAE; Lisa Meline, P.E., Member ASHRAE

This is the final installment in a series that summarizes a data collection and analysis project to identify common characteristics of successful ground source heat pump (GSHP) systems.

The goals of GSHP systems are common to conventional HVAC systems and include the following:

- Low building energy consumption and costs;
- Installation costs that are economically viable in relatively short time periods;
- Room conditions that are satisfactory to occupants; and
- Minimal maintenance requirements and costs.

Finding good data for this project was challenging because typical measures of success identified in the list of goals were either not accessible or made unavailable for GSHPs (and traditional HVAC systems) that did not perform

buildings was able to obtain actual energy data for only 121 out of 585 buildings requested.¹ The authors posed the question, "Why is it so hard...to get this information for the buildings being profiled?"

Every electric utility encountered in this survey had the necessary information. The hitch was the building owner needed to approve access, and in some cases, the owner chose not to do so. The information on installation costs was even more restricted than the utility data.

From the survey, it may be surmised that:

- A reason it is so hard to obtain energy data (and costs) is that in some cases "...the buildings are using significantly

ers, contractors, and owners are unwilling to share results.

- Designers, contractors, and owners willing to share energy and costs data are likely to have completed successful GSHP projects with good energy performance (i.e., high ENERGY STAR rating) and reasonable first costs.

- The average ENERGY STAR ratings for the GSHP buildings surveyed in this study may be higher than the average of GSHP systems (because of the first two items).

However, the average could potentially be much higher if owners (and architects) were able to choose engineers based on quantifiable information. Publication of energy data, installation

About the Authors

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