Geothermal Heat Pumps
GHP-101

meline engineering

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What Makes it a Geothermal Heat Pump System?

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

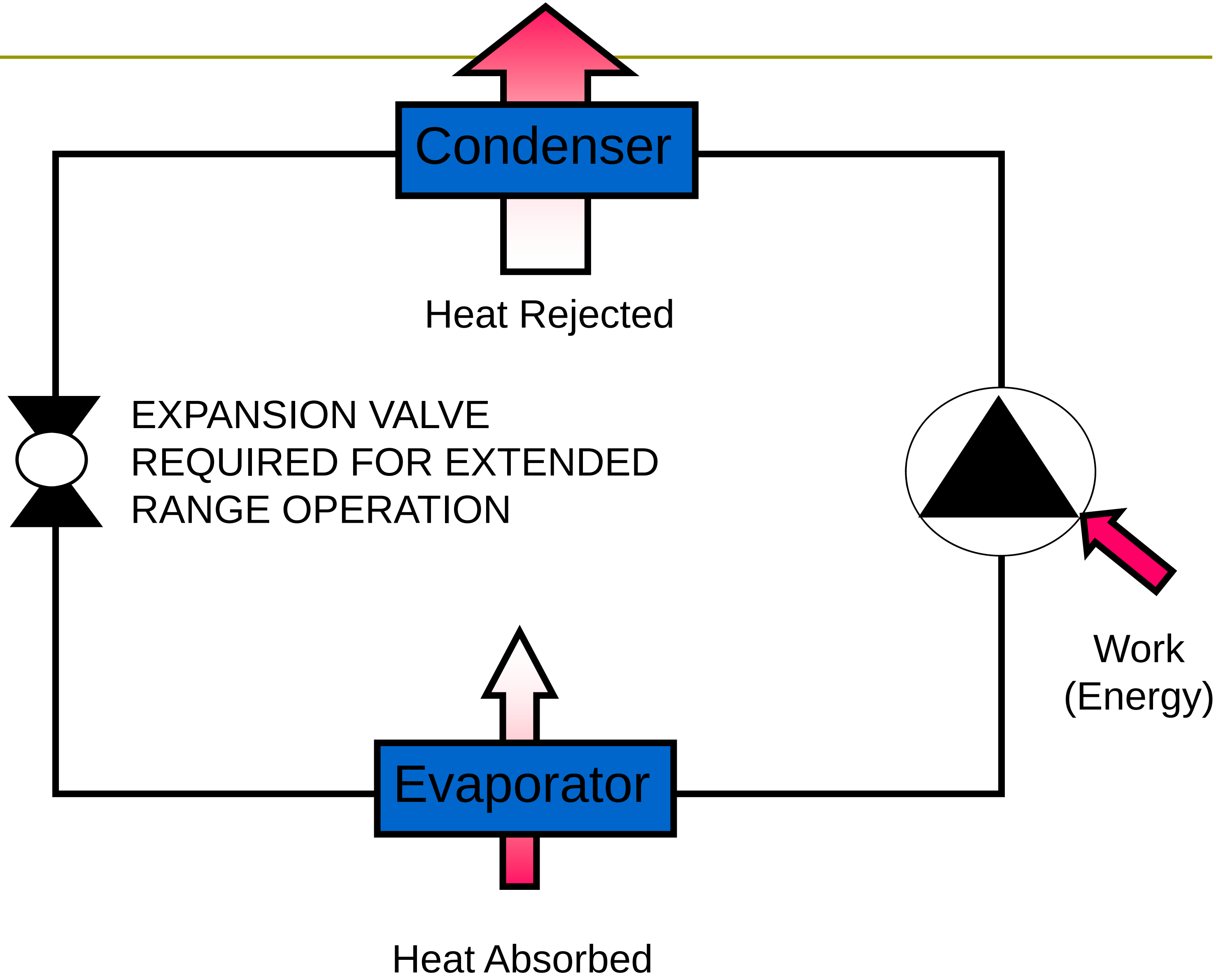
Geothermal Heat Pump Equipment

Photo courtesy of Water Furnace

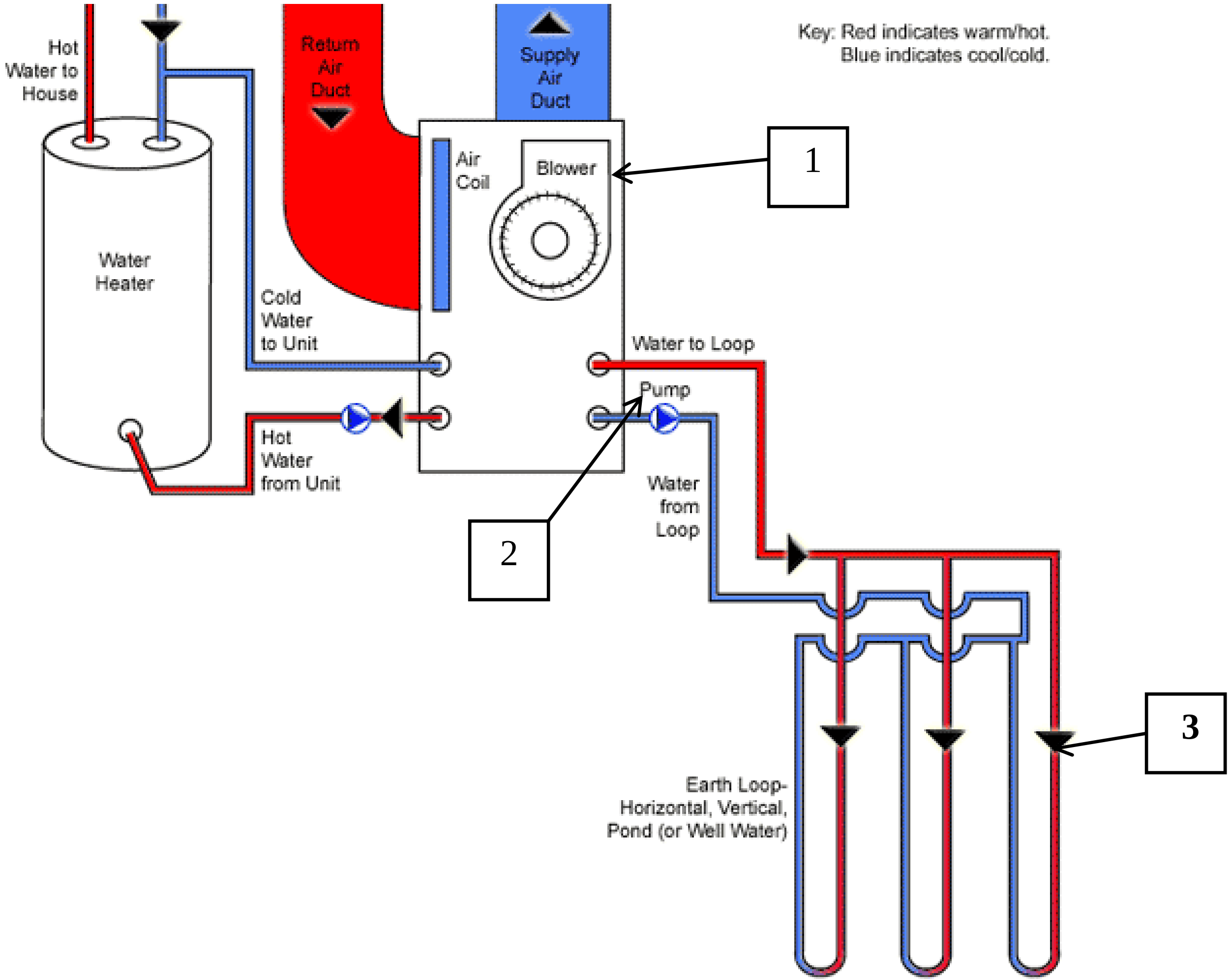
Geothermal Heat Pumps:

- 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/Wc = the heat delivered (or removed) divided by the work of the compressor

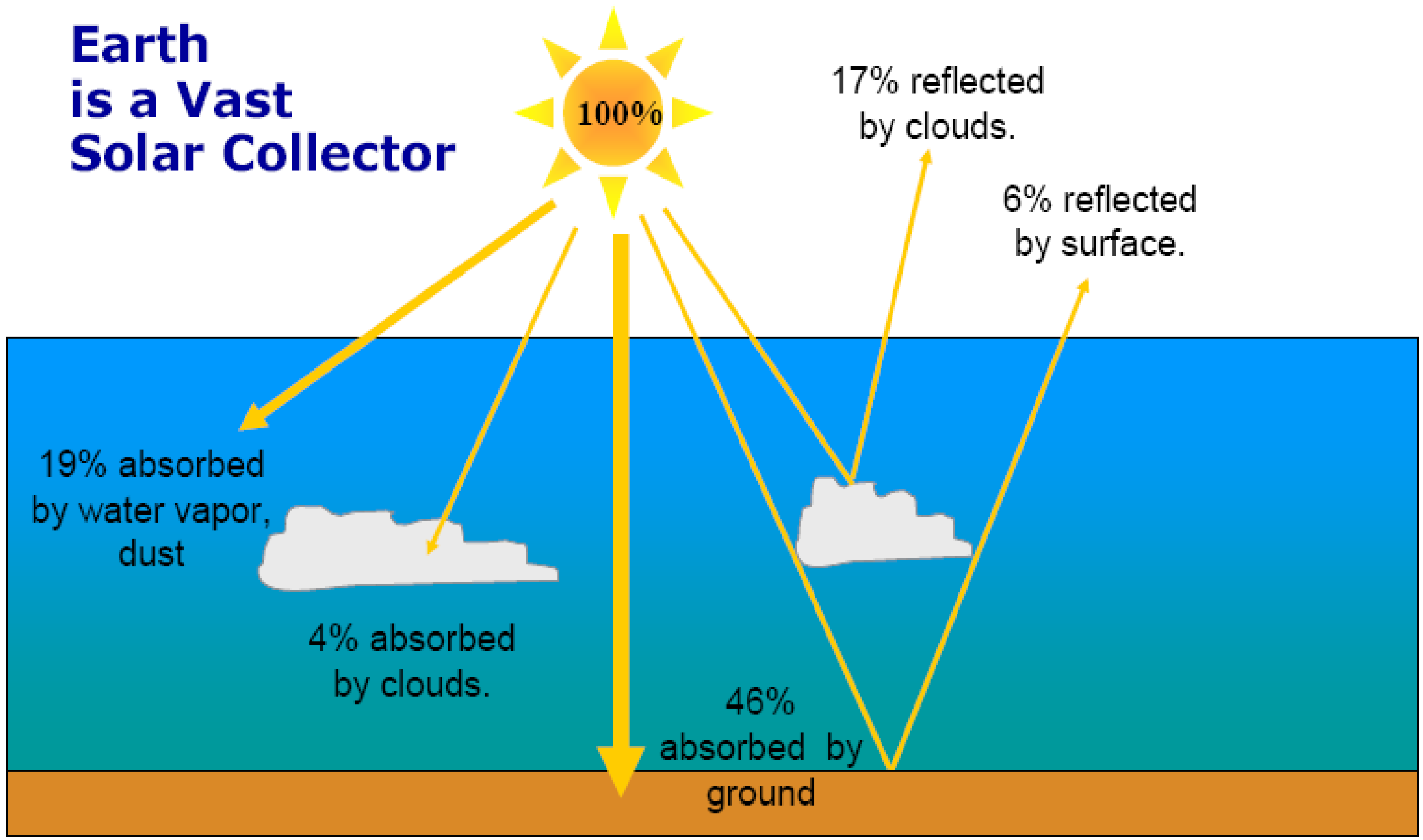
- Energy Efficiency Rating (EER)

  Wc/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

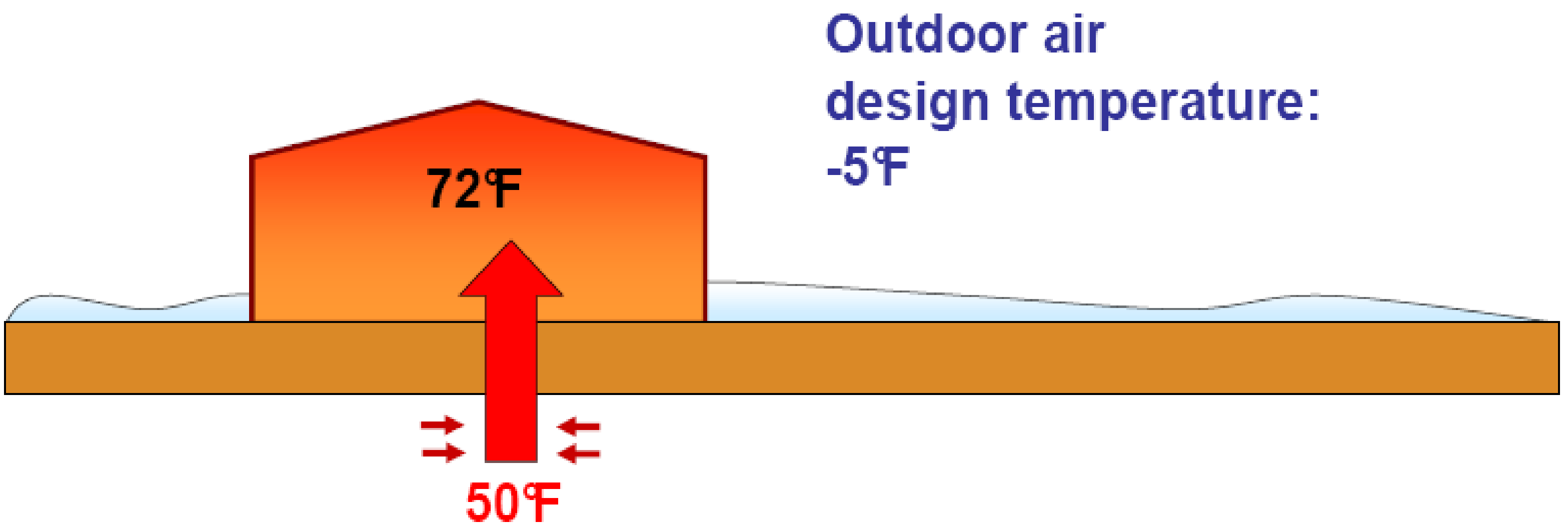
The Loop -
The Renewable Connection



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

Diagram courtesy of FHP Bosch

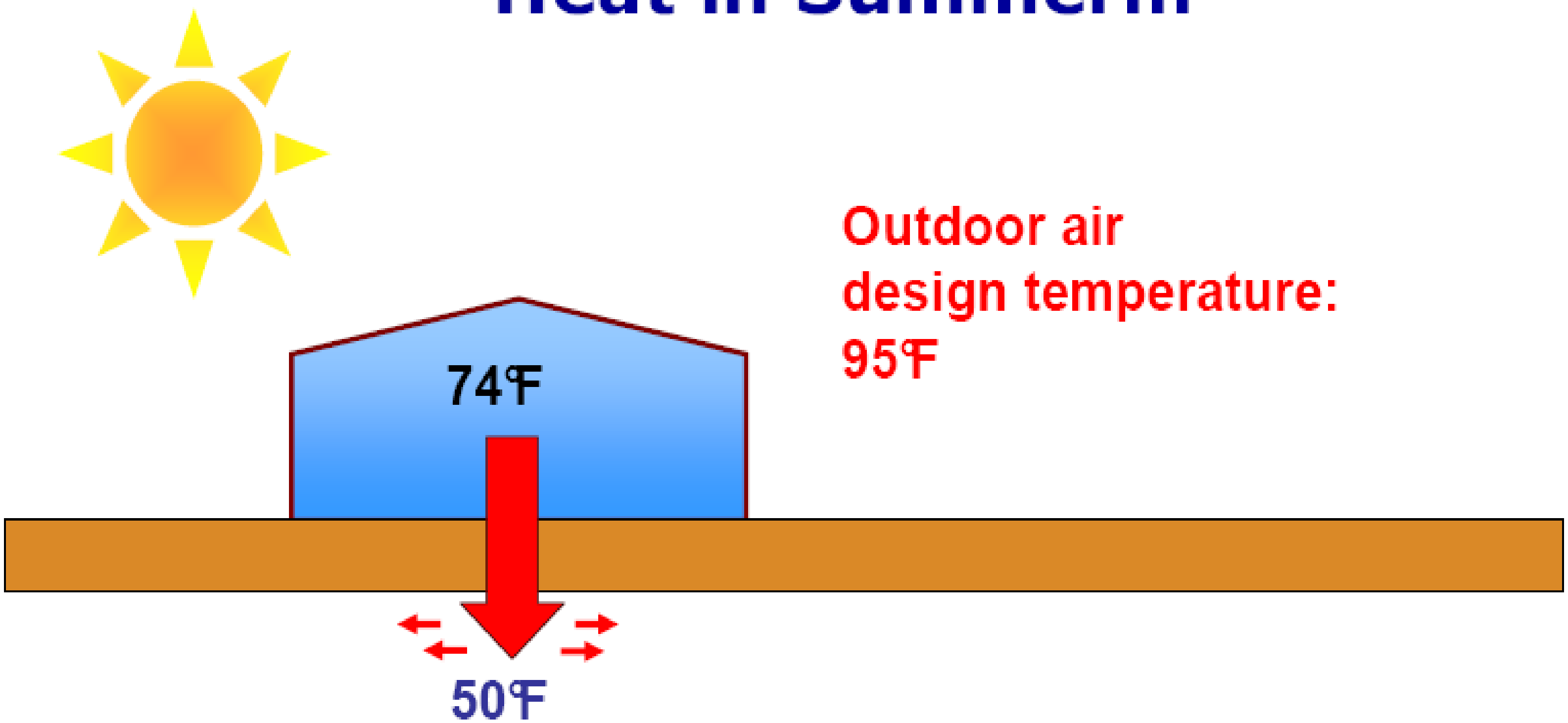
The Earth is a Source of Heat in Winter…



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

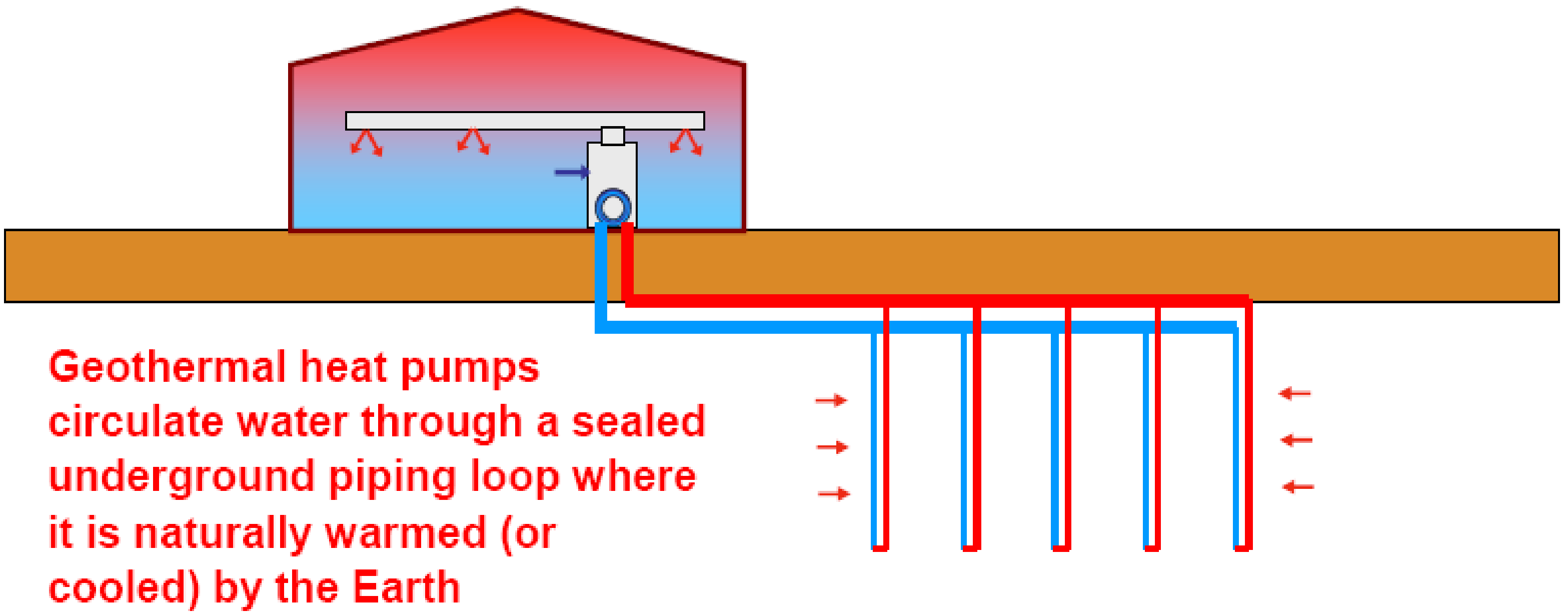
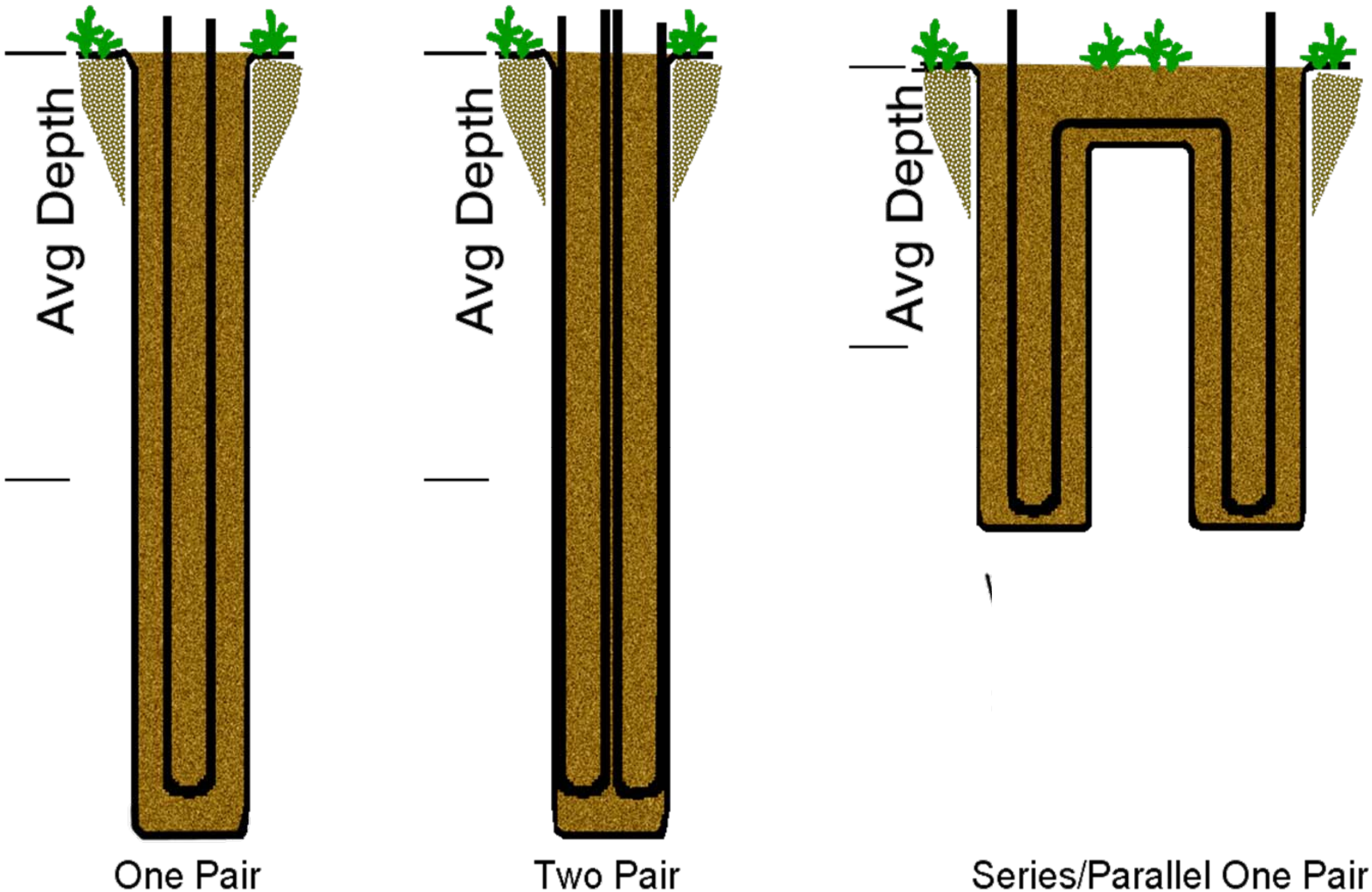


Diagram courtesy of FHP Bosch

Vertical Loop Examples



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

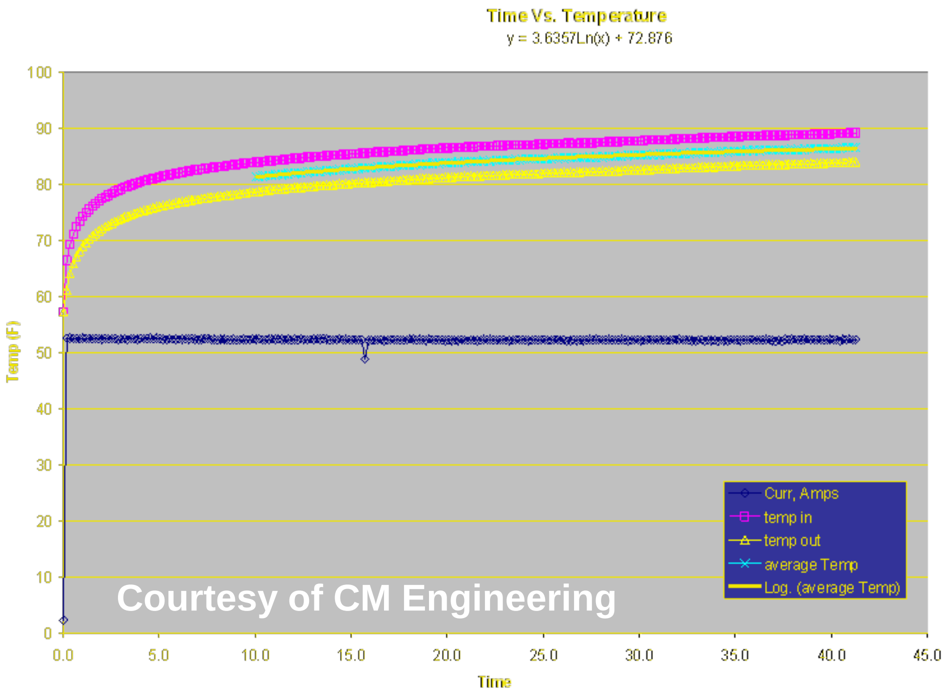
How Do We Design ‘The Loop’

- 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

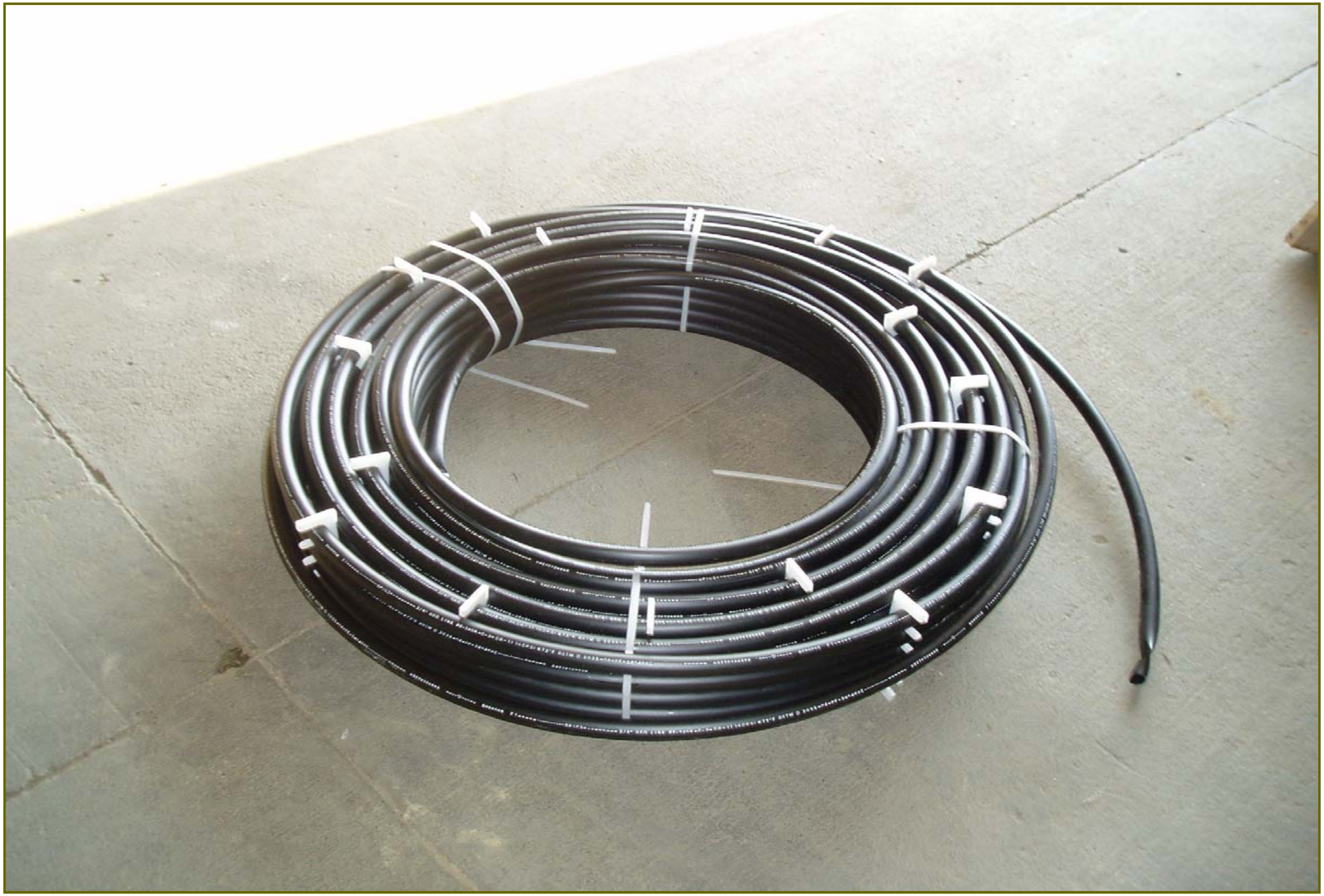
Topsoil	0-3
Brown Sandy Clay	3-27
Gray Sticky Clay with Sand	27-62
Coarse Gray Sand, Gravel, and Cobbles-Water Bearing	62-89
Gray/Brown Limestone	89-265
Gray Dolomite	265-368
Blue-Gray Dolomite	368-375
Gray/Light Gray Sandstone	375-426
Tan Sandstone	426-500

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

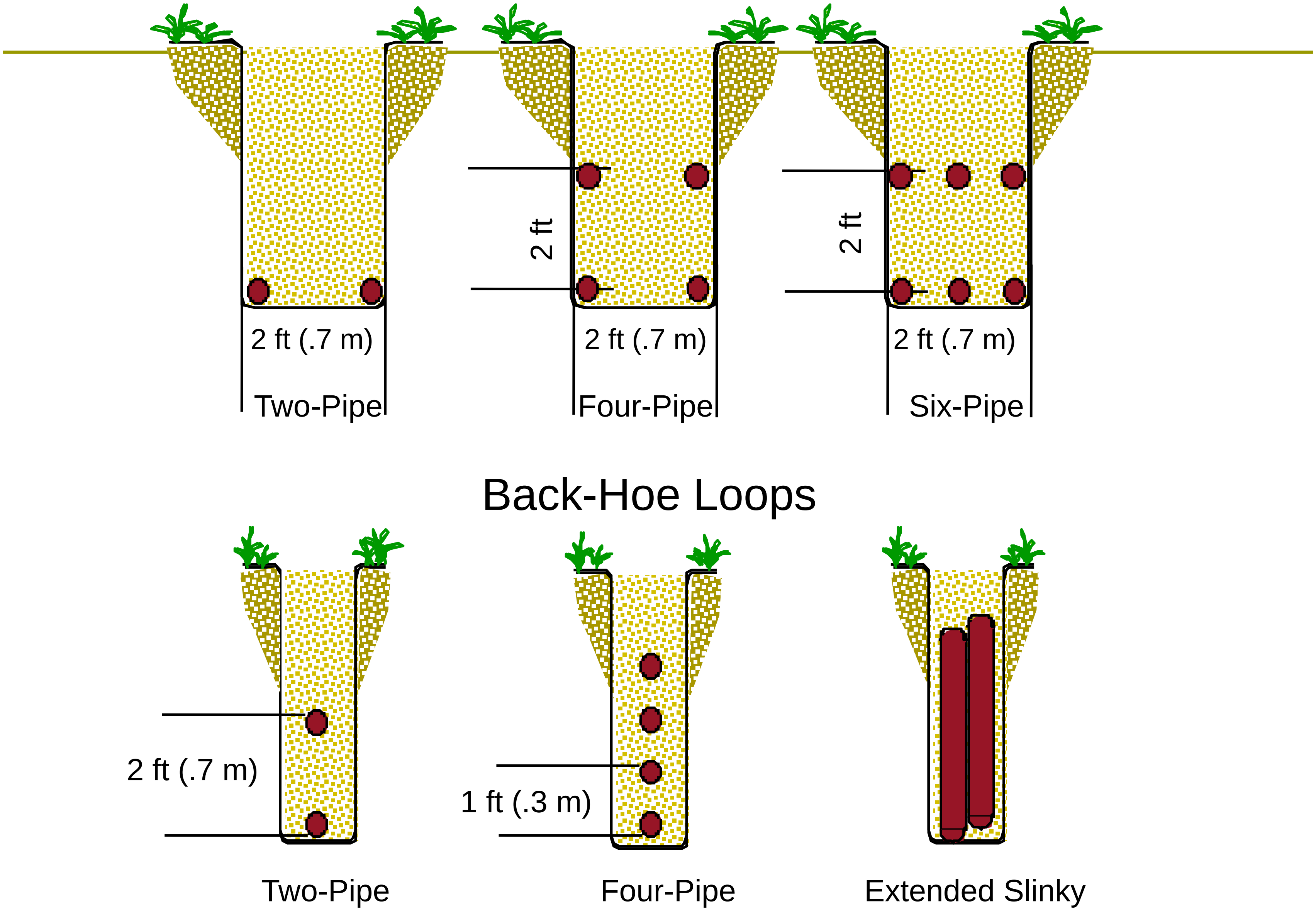
Surface Water (Pond) Loops

HDPE Coils or…



a Closed- Loop Plate Heat Exchanger?

Horizontal Loop Types

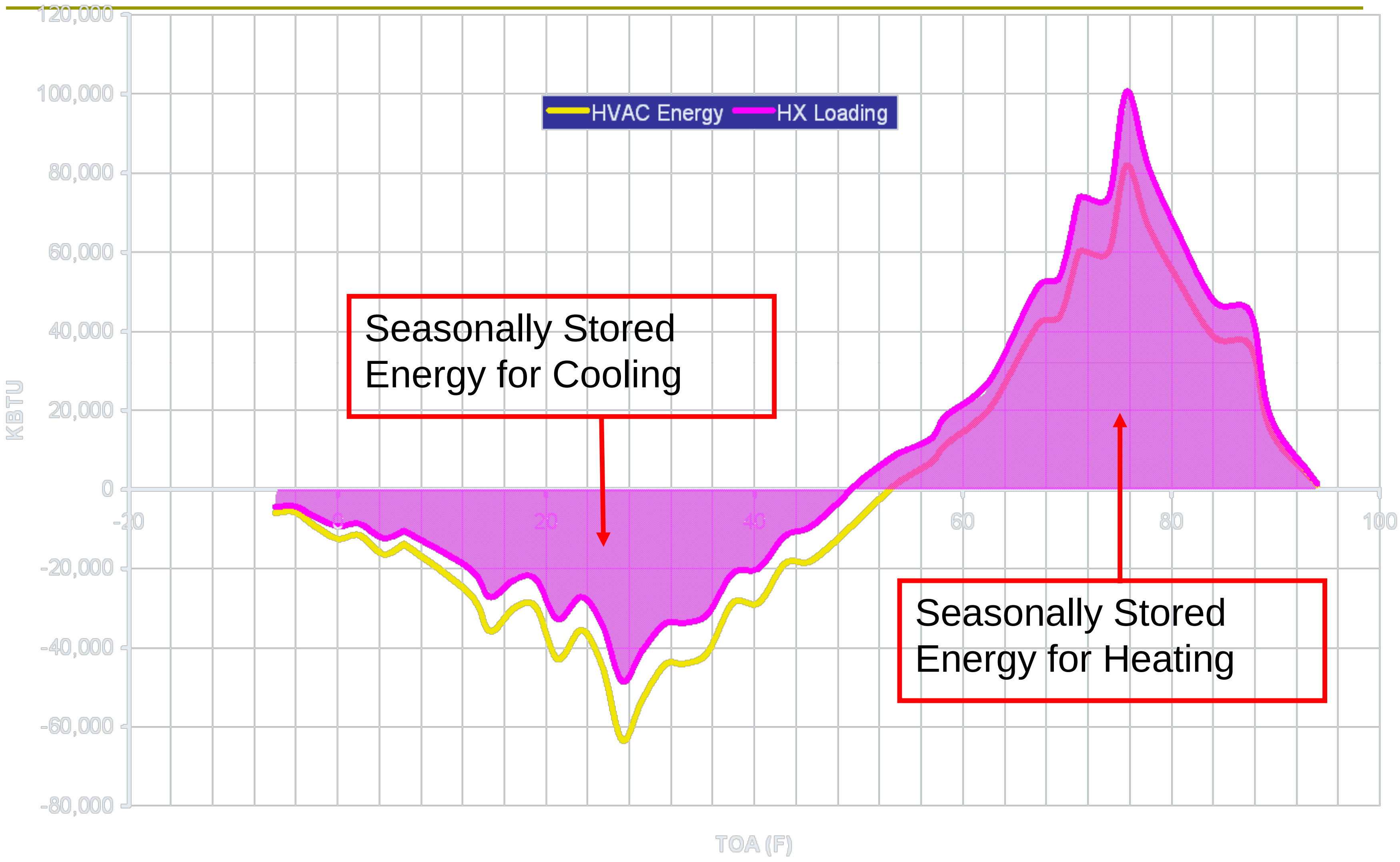


Slinky Loop

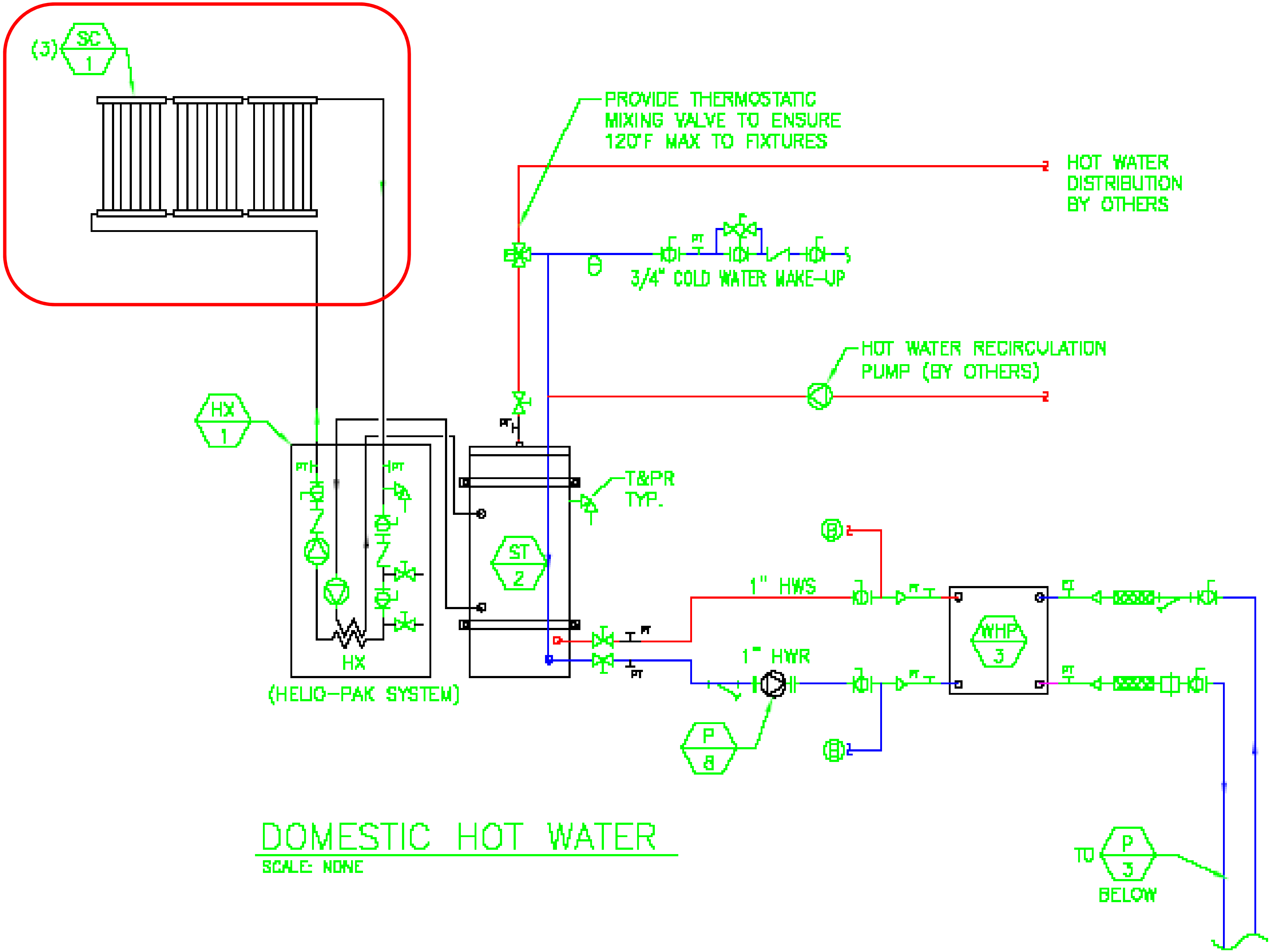
Horizontal or Directional Drilling

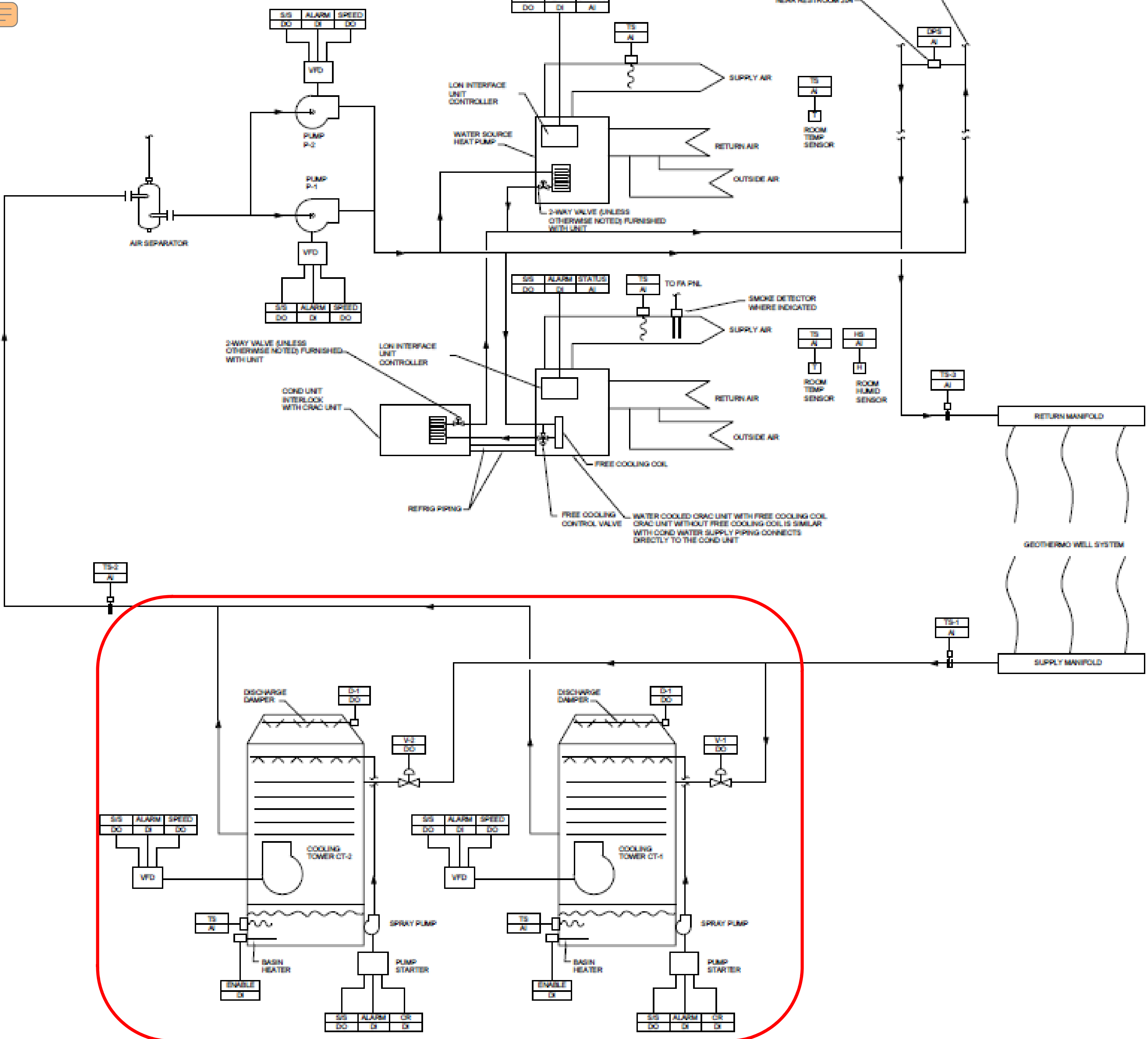
Horizontal Drilling - continued

Seasonal Energy Usage



Hybrid GHP Systems




S/S DO
ALARM DI
SPEED DO
STATUS AI
VFD
PUMP P-2
PUMP P-1
AIR SEPARATOR
LON INTERFACE UNIT CONTROLLER
WATER SOURCE HEAT PUMP
TS AI
DPS AI
SUPPLY AIR
RETURN AIR
OUTSIDE AIR
ROOM TEMP SENSOR
2-WAY VALVE (UNLESS OTHERWISE NOTED) FURNISHED WITH UNIT
TO FA PNL
SMOKE DETECTOR WHERE INDICATED
HS AI
ROOM HUMID SENSOR
COND UNIT INTERLOCK WITH CRAC UNIT
FREE COOLING COIL
REFRIG PIPING
FREE COOLING CONTROL VALVE
WATER COOLED CRAC UNIT WITH FREE COOLING COIL CRAC UNIT WITHOUT FREE COOLING COIL IS SIMILAR WITH COND WATER SUPPLY PIPING CONNECTS DIRECTLY TO THE COND UNIT
TS-3 AI
RETURN MANIFOLD
GEOTHERMO WELL SYSTEM
SUPPLY MANIFOLD
TS-1 AI
TS-2 AI
DISCHARGE DAMPER
D-1 DO
V-1 DO
V-2 DO
COOLING TOWER CT-2
COOLING TOWER CT-1
SPRAY PUMP
BASIN HEATER
ENABLE DI
PUMP STARTER
CR DI

Life Cycle Cost and Equipment Lifetime

Owning and Operating Costs

Table 4 Comparison of Service Life Estimates

Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)
Air Conditioners		
Window unit	N/A*	10
Residential single or split package	N/A*	15
Commercial through-the-wall	N/A*	15
Water-cooled package	>24	15
Heat pumps		
Residential air-to-air	N/A*	15[b]
Commercial air-to-air	N/A*	15
Commercial water-to-air	>24	19
Roof-top air conditioners		
Single-zone	N/A*	15
Multizone	N/A*	15
Boilers, Hot-Water (Steam)		
Steel water-tube	>22	24 (30)
Steel fire-tube		25 (25)
Cast iron	N/A*	35 (30)
Electric	N/A*	15
Burners	N/A*	21
Furnaces		
Gas- or oil-fired	N/A*	18
Unit heaters		
Gas or electric	N/A*	13
Hot-water or steam	N/A*	20
Radiant heaters		
Electric	N/A*	10
Hot-water or steam	N/A*	25

Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)
Air Terminals		
Diffusers, grilles, and registers	N/A*	27
Induction and fan-coil units	N/A*	20
VAV and double-duct boxes	N/A*	20
Air washers	N/A*	17
Ductwork	N/A*	30
Dampers	N/A*	20
Fans	N/A*	
Centrifugal	N/A*	25
Axial	N/A*	20
Propeller	N/A*	15
Ventilating roof-mounted	N/A*	20
Coils		
DX, water, or steam	N/A*	20
Electric	N/A*	15
Heat Exchangers		
Shell-and-tube	N/A*	24
Reciprocating compressors	N/A*	20
Packaged Chillers		
Reciprocating	N/A*	20
Centrifugal	>25	23
Absorption	N/A*	23
Cooling Towers		
Galvanized metal	>22	20
Wood	N/A*	20
Ceramic	N/A*	34

Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)
Condensers		
Air-cooled	N/A	20
Evaporative	N/A*	20
Insulation		
Molded	N/A*	20
Blanket	N/A*	24
Pumps		
Base-mounted	N/A*	20
Pipe-mounted	N/A*	10
Sump and well	N/A*	10
Condensate	N/A*	15
Reciprocating engines	N/A*	20
Steam turbines	N/A*	30
Electric motors	N/A*	18
Motor starters	N/A*	17
Electric transformers	N/A*	30
Controls		
Pneumatic	N/A*	2[illegible]
Electric	N/A*	1[illegible]
Electronic	N/A*	1[illegible]
Valve actuators		
Hydraulic	N/A*	1[illegible]
Pneumatic	N/A*	2[illegible]
Self-contained		1[illegible]

...kalin (1978) for these categories may be outdated and not statistically relevant. Use these data with

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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