SESSION E04

Time for Geo?

STEVEN GUNTHER, PE, LEED GA

Strategic Energy Solutions®

About Me:

From Midland, Michigan

Masters in Architectural Engineering from Lawrence Technological University

Served on the Board of Education for Melvindale-Northern Allen Park Public Schools from 2017-2020

About SES:

26 years of MEP engineering experience

25 years of geothermal experience

Served more than 160 K12 districts & institutions

Team includes: Certified Geothermal Designers, Installers, and Inspectors

54
Geo Feasibility Studies

63
Geo Designs Completed

37
Ground Loops Installed

About You:

People

- Director of Operations
- Facility Directors
- Maintenance Staff
- Central Office Staff
- Architects/Engineers

District Information

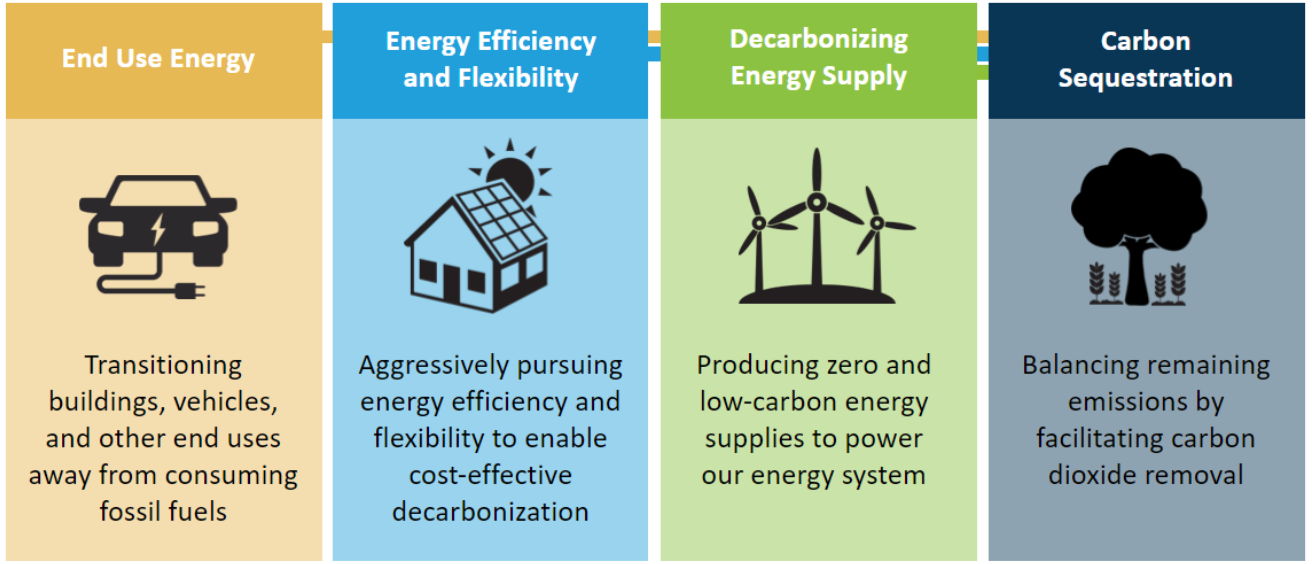
- Sustainability Initiatives and Goals
  - Energy Reduction (Cost)
  - Energy Reduction (Energy)
  - Carbon Footprint

Topics for Today:

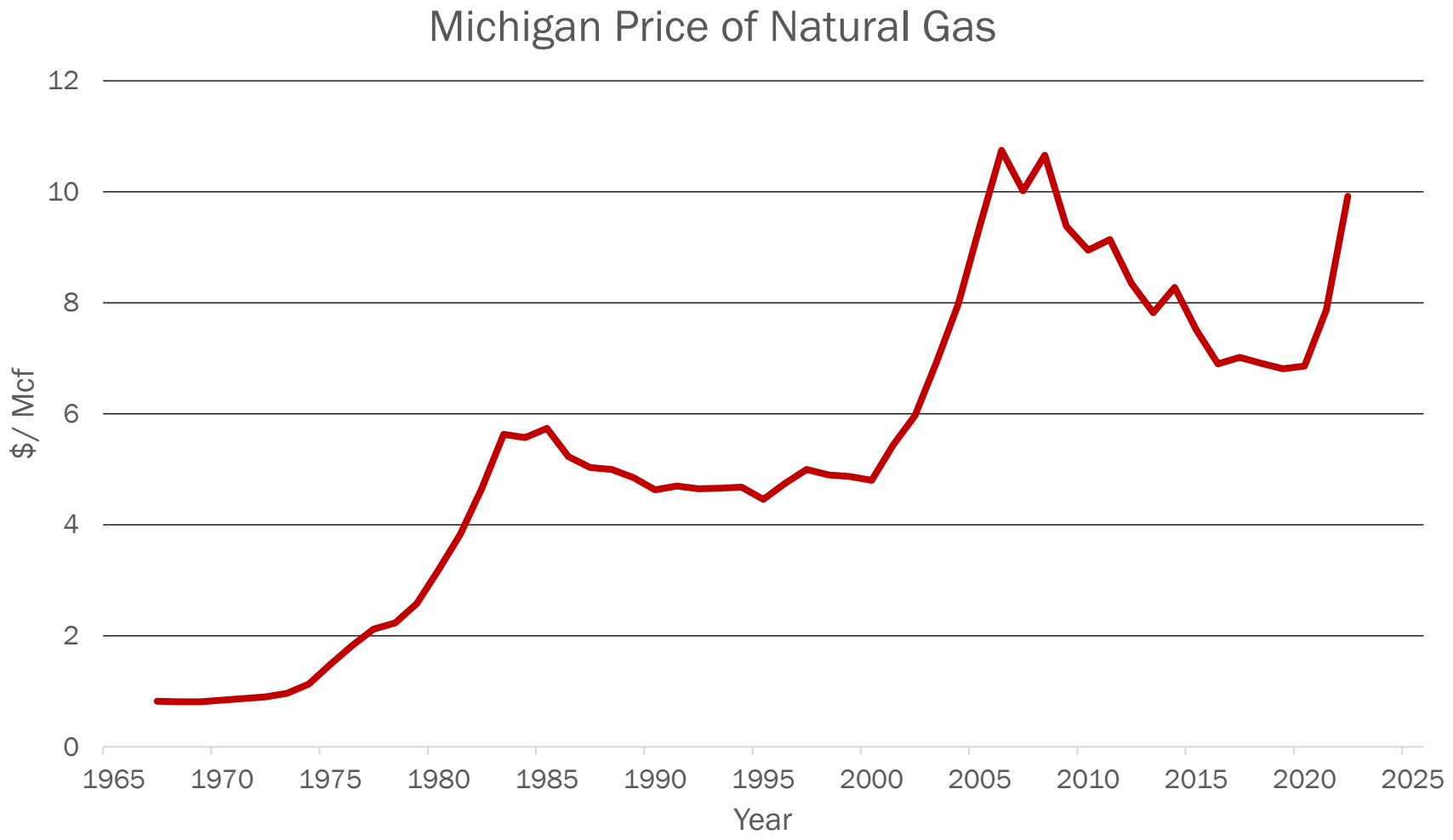
- Why is this Important?
- What is a geothermal system and how does it operate?
- Benefits of geothermal systems
- Cost Impacts
- K-5 Case Study
- What to look for in your geothermal design team and the drawings you receive

Why Is This Important?

1. **Decarbonization**
   - Reduce our carbon footprint today to preserve the environment for current K-12 students
2. **Combat the rising cost of utility provided energy**
   - Reduce energy usage
   - Reduce energy costs
   - Reduce maintenance costs
3. **School districts are the fiduciary for taxpayer funds**
   - Reduced operating budgets = more money to students
   - Reduced energy costs = more money to capital projects
4. **Schools are 50+ year buildings**

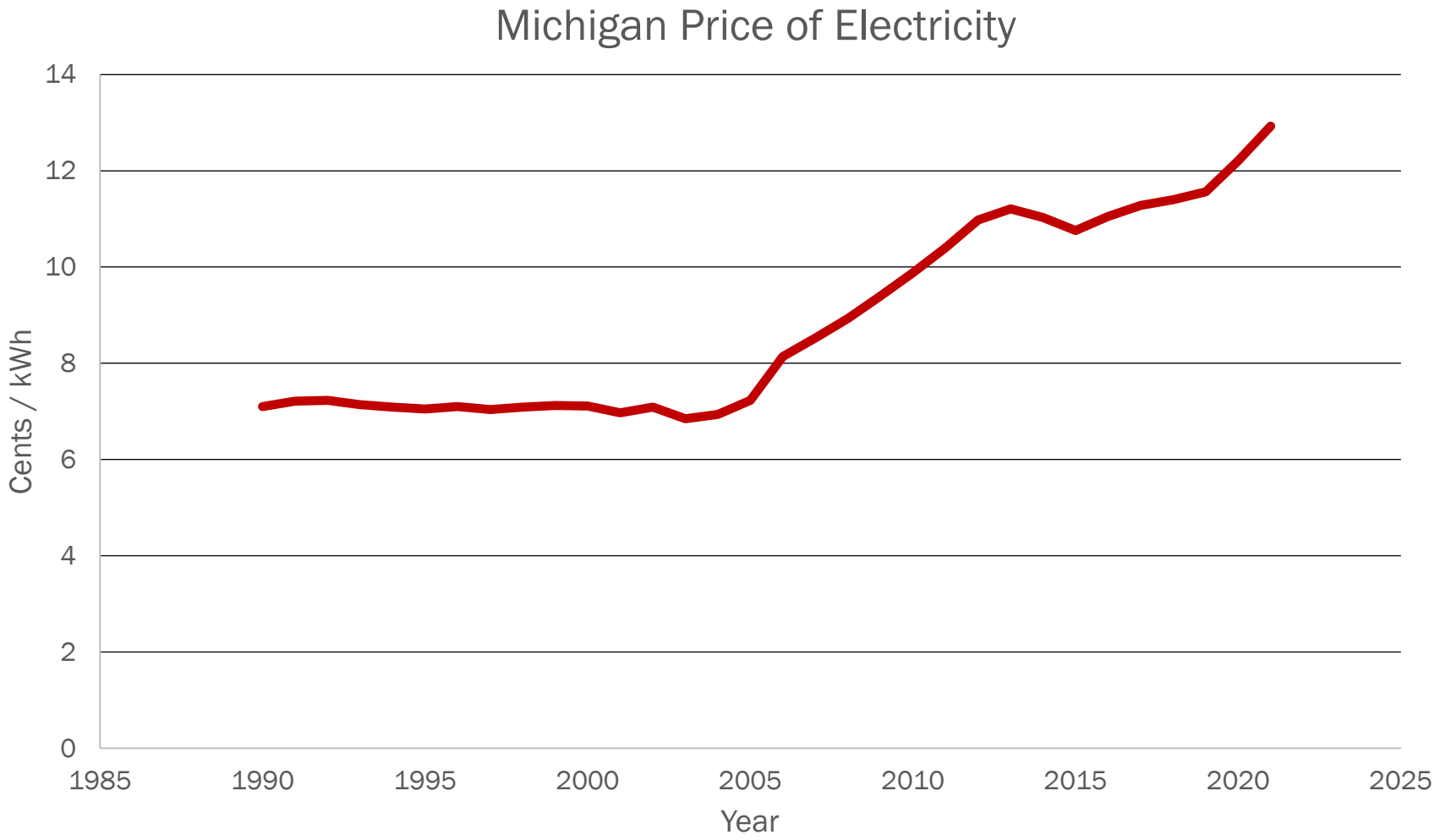


Why Is This Important?



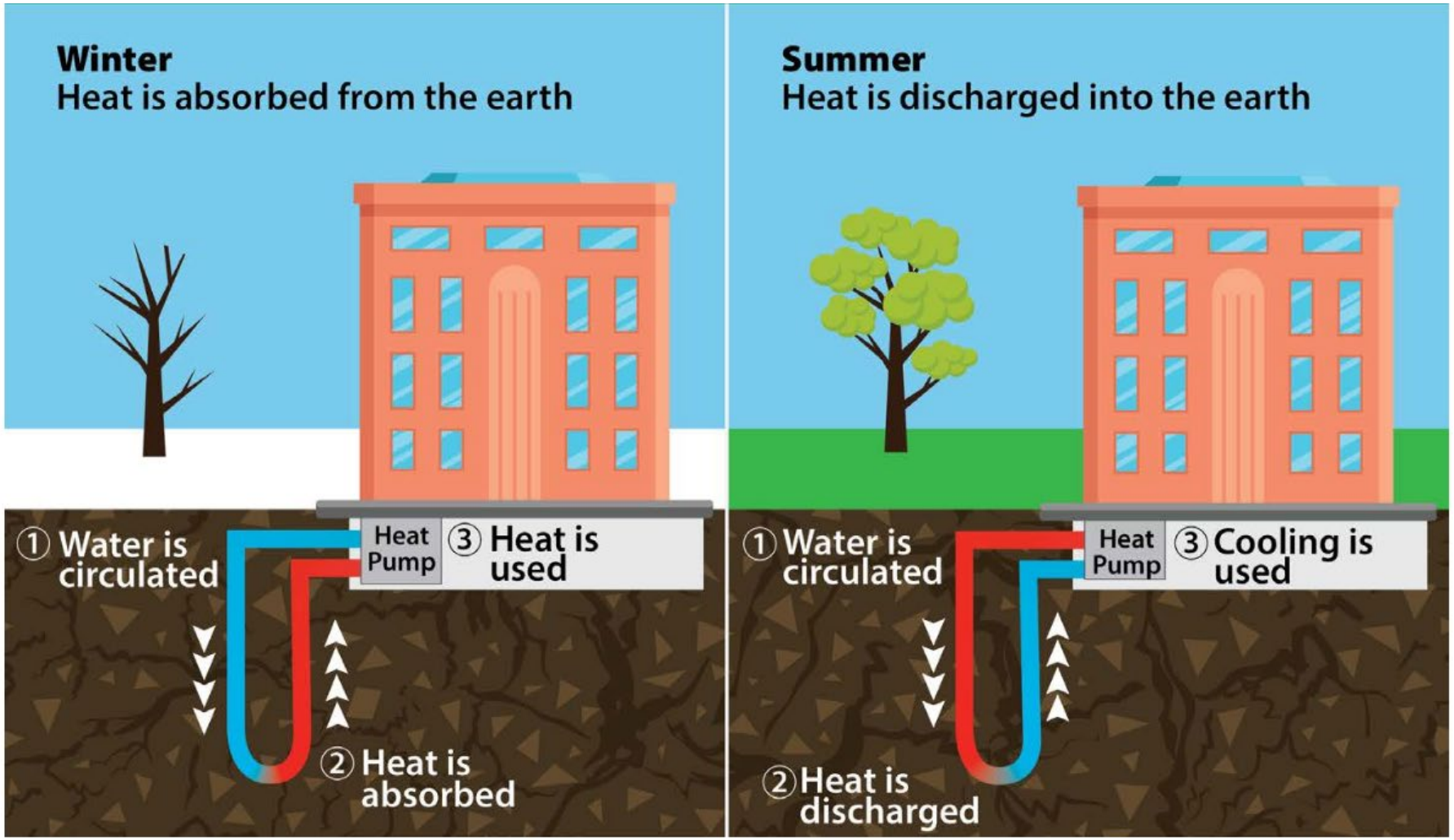
Source: https://www.eia.gov/dnav/ng/hist/n3020mi3a.htm

Why Is This Important?



Source: https://www.eia.gov/electricity/state/michigan/

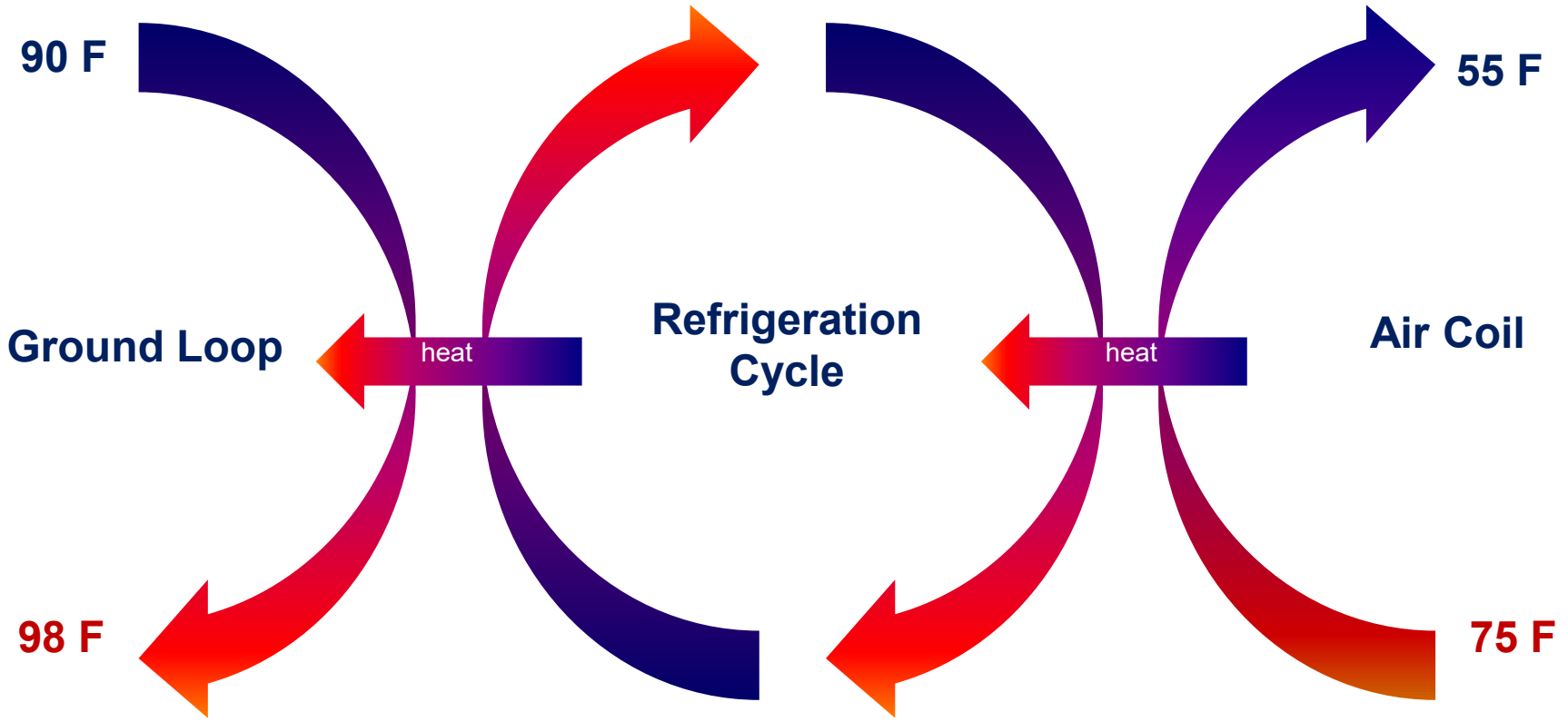
Geothermal System:



Geothermal System:

COOLING:

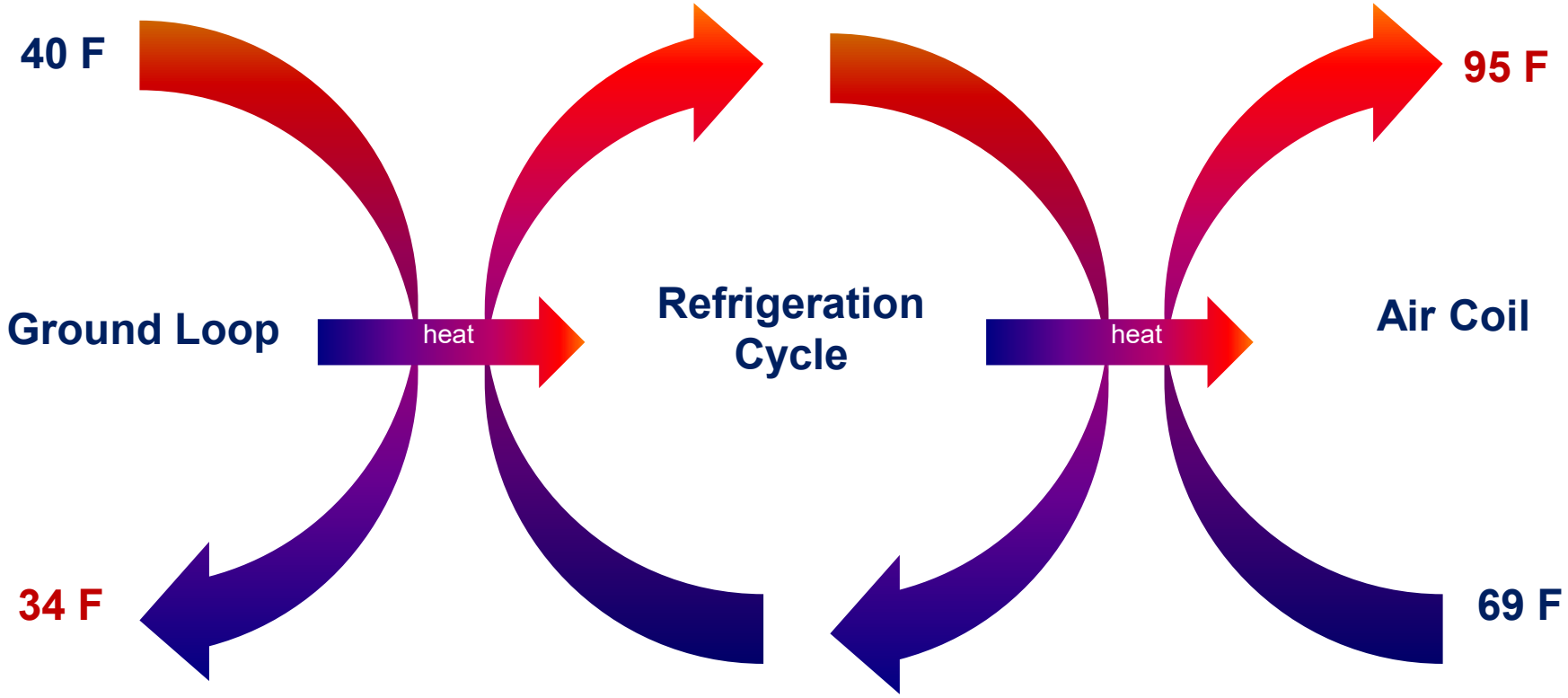
- Works on same principle as any other refrigerator or air conditioner
- Heat is rejected to the water loop instead of ambient air
- Higher efficiency, longer compressor life



Geothermal System:

HEATING:

- Works on same principle as any other refrigerator or air conditioner in reverse
- The 40 degree water is cooled
- Heat is rejected to the supply air



Geothermal System:

Closed Ground Loop

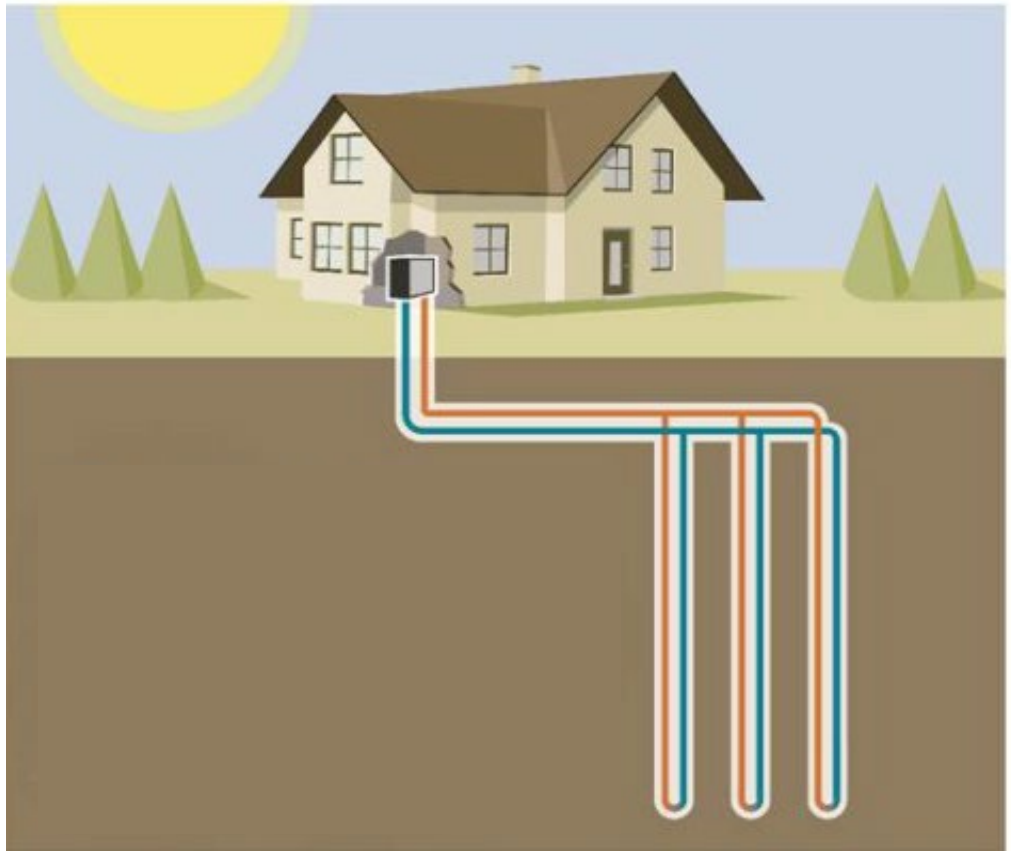
- Vertical
  - Fully Grouted, 6” Ø
  - 20’ spacing
  - 400’ – 600’ deep
- Horizontal
  - Slinky or Direction Bore
  - Buried approx. 5’ – 10’ below grade
- Pond
  - Slinky or Plate
  - Submerged in bottom of pond

Open Ground Loop

- Water Well Loop

Geothermal System:

Vertical Ground Loop



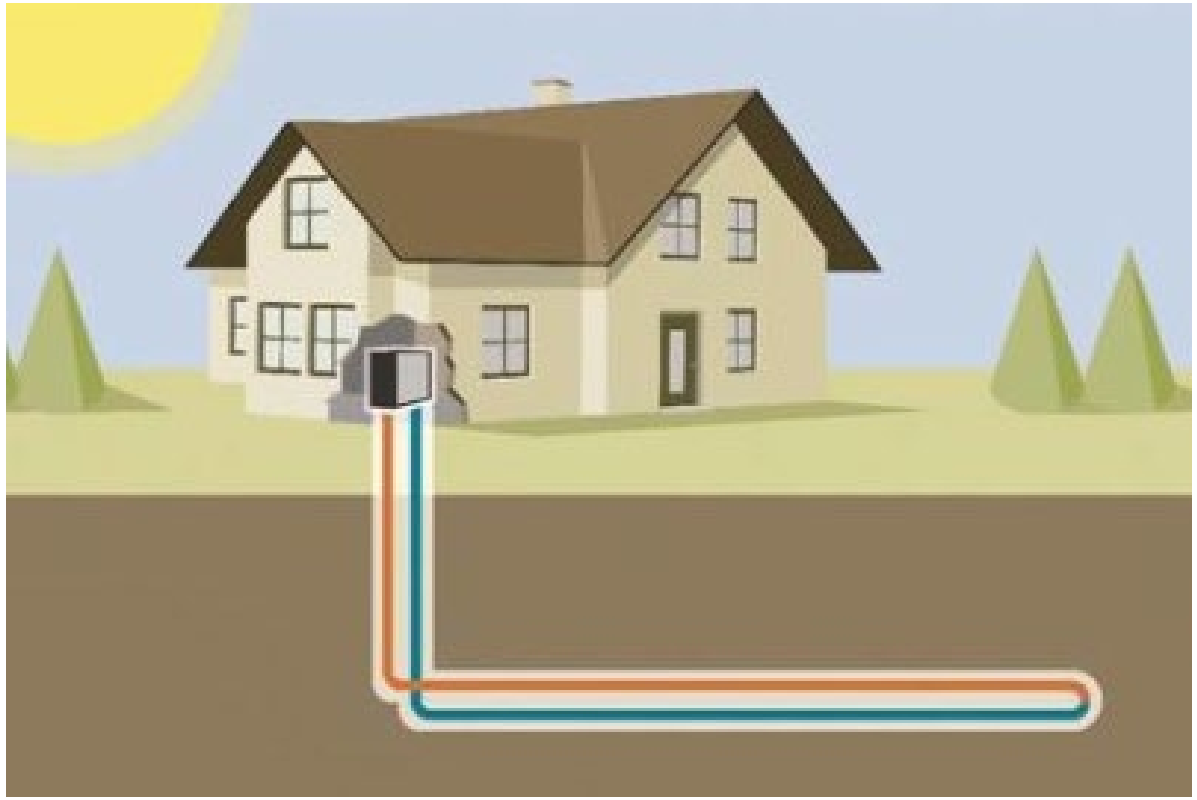
Horizontal Pipe Header

~ 5ft Trench

Vertical Bore

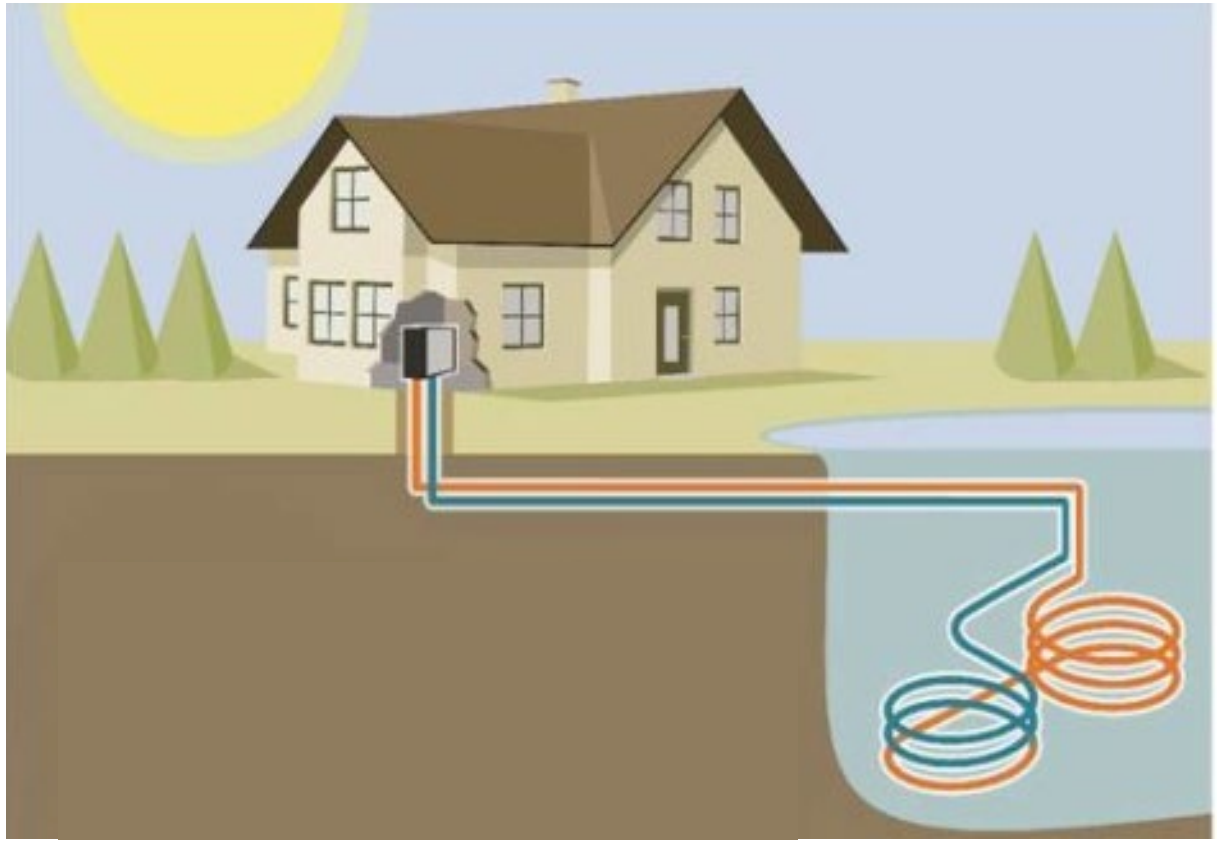
Geothermal System:

Horizontal Ground Loop



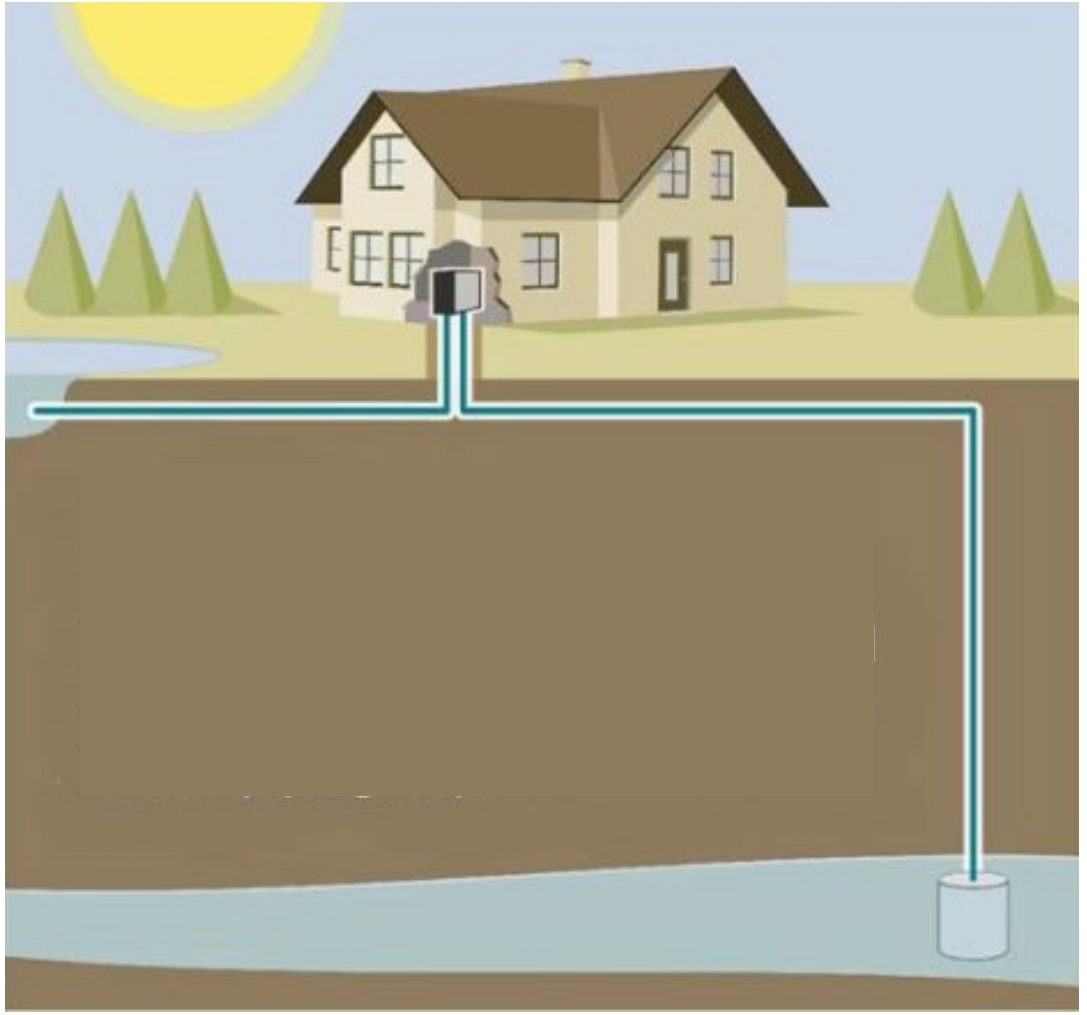
Geothermal System:

Pond Loop



Geothermal System:

Water Well Loop



Geothermal System:

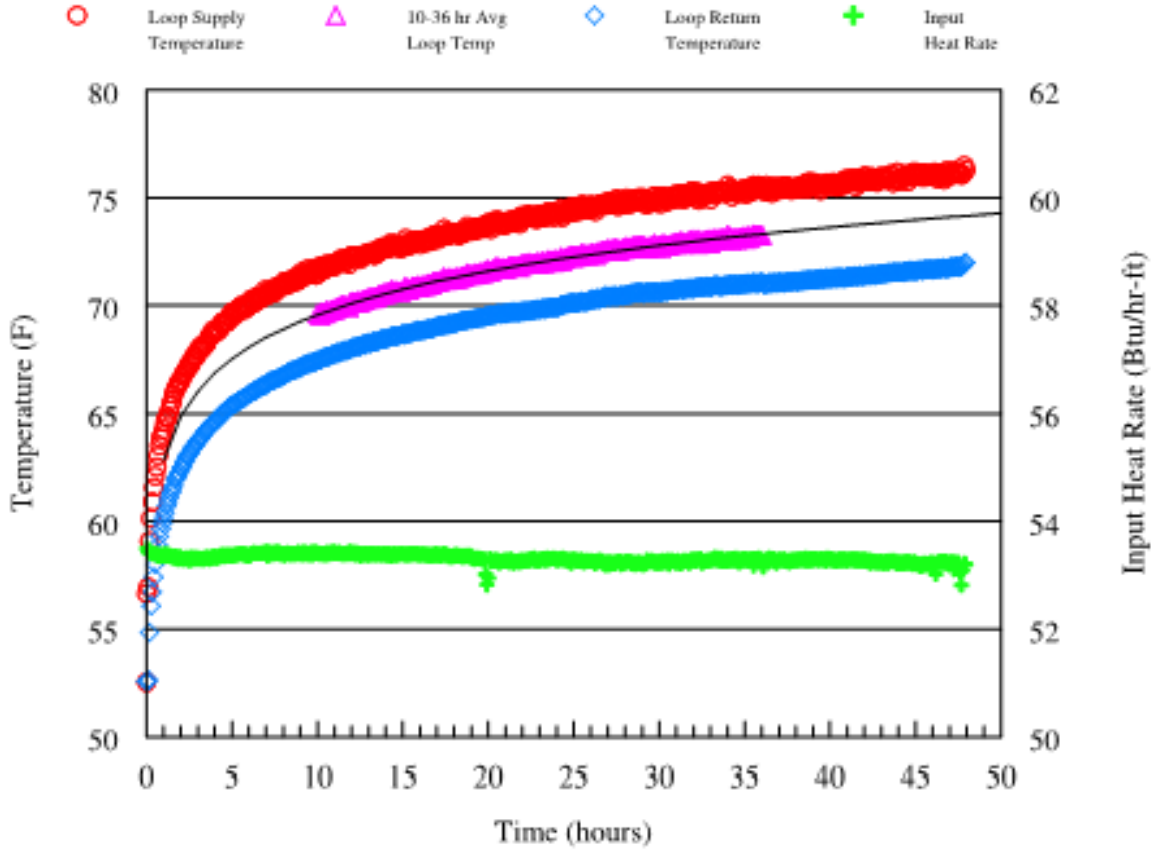
Field Installation: Step 1 – FTC Test

- Formation Thermal Conductivity test
- Determines the drilling condition and formations encountered
- Determines the deep earth temperature, conductivity and diffusivity of the earth
- Test bore is then incorporated into the final system
- Contractors can bid drilling work with less risk
- Engineers can design with less safety factor on thermal conductivity.
- Start test 5 days after drilling the bore
- The test is min. of 40 hour

Geothermal System:

Field Installation: Step 1 – FTC Test

Thermal Conductivity Test Data



Drill Log

Formation Description	Depth (ft)
Clay	0'-9'
Gravel	9'-12'
Clay	12'-30'
Clay/gravel mix	30'-36'
Sandy clay	36'-56'
Sand	56'-66'
Sand/gravel mix	66'-90'
Sand	90'-158'
Gravel (packed)	158'-160'
Sand/gravel mix	160'-180'
Gravel (packed)	180'-184'
Sand/gravel mix	184'-235'
Sandy clay	235'-250
Limestone	250'-254'
Shale with limestone stringers	254'-400'

Geothermal System:

Field Installation: Step 2 – DLG

- Drill Loop Grout
- Drill 6” Ø hole deep into the earth
- HDPE piping loop (2 pipes with U-fitting at the bottom) is inserted down into the hole. Piping is typically 1 ¼” Ø. U-bend loops are prefabricated and factory pressure tested.
- The voided space is filled with thermally enhanced grout, which leaves the u-tube in solid contact with the surrounding earth.
- Sealed u-tubes are left exposed for next step.

Geothermal System:

Field Installation: Step 3 – THM

- Trench, Header, Manifold
- Header piping is assembled and placed in trenches adjacent to the vertical bores.
- Each length of trench is typically one circuit.
- The circuits are then joined together at the manifold inside the building.
- All pipe joints and connections are fusion welded leaving no mechanical joints or fittings underground.

Geothermal System:

Main HVAC System Components

- **Geothermal Manifold**
  - Entry point for all piping coming into the building from the ground
  - Typically located in the mechanical room near the pumps
- **System Pump**
  - Circulate fluid (water or water with glycol) between the field and building components
- **Heat Pump Coil**
  - Water to Water or Water to Air
  - Incorporate as part of stand-alone unit (AKA “Heat Pump”), AHU, or unit ventilator
- **DOAS Unit**
  - Dedicated Outdoor Air Unit
  - Energy Recovery Wheel
  - Indoor or Outdoor
  - Option for geothermal heat pump coil for discharge air conditioning

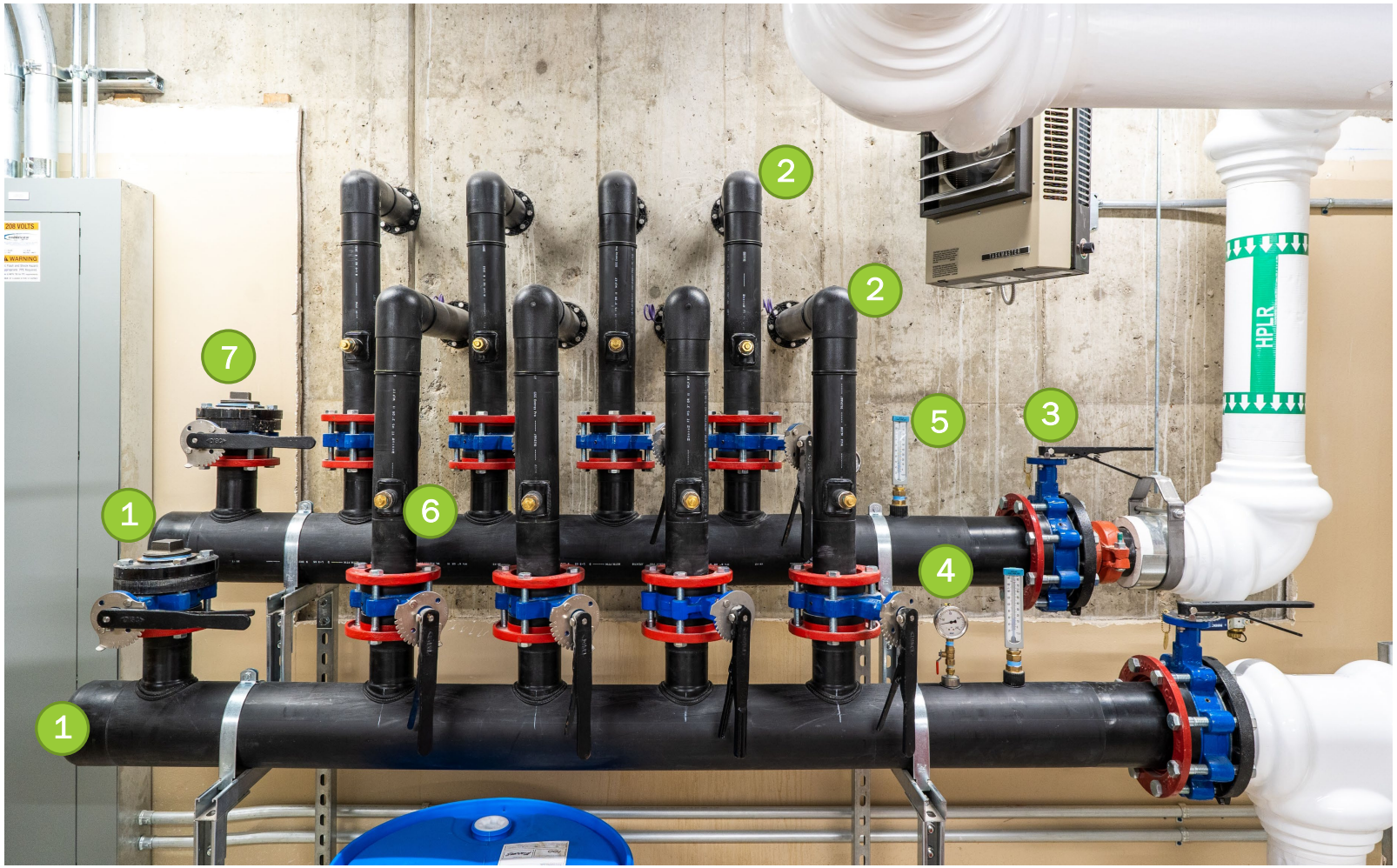
DOAS UNIT

WATERSOURCE HEAT PUMP

Geothermal System:

Geothermal Manifold

1. Supply/Return Header
2. Supply/Return Circuit
3. Isolation Valve (Typ)
4. Pressure Gauge
5. Thermometer
6. PT Test Port
7. Charging Station



Geothermal System:

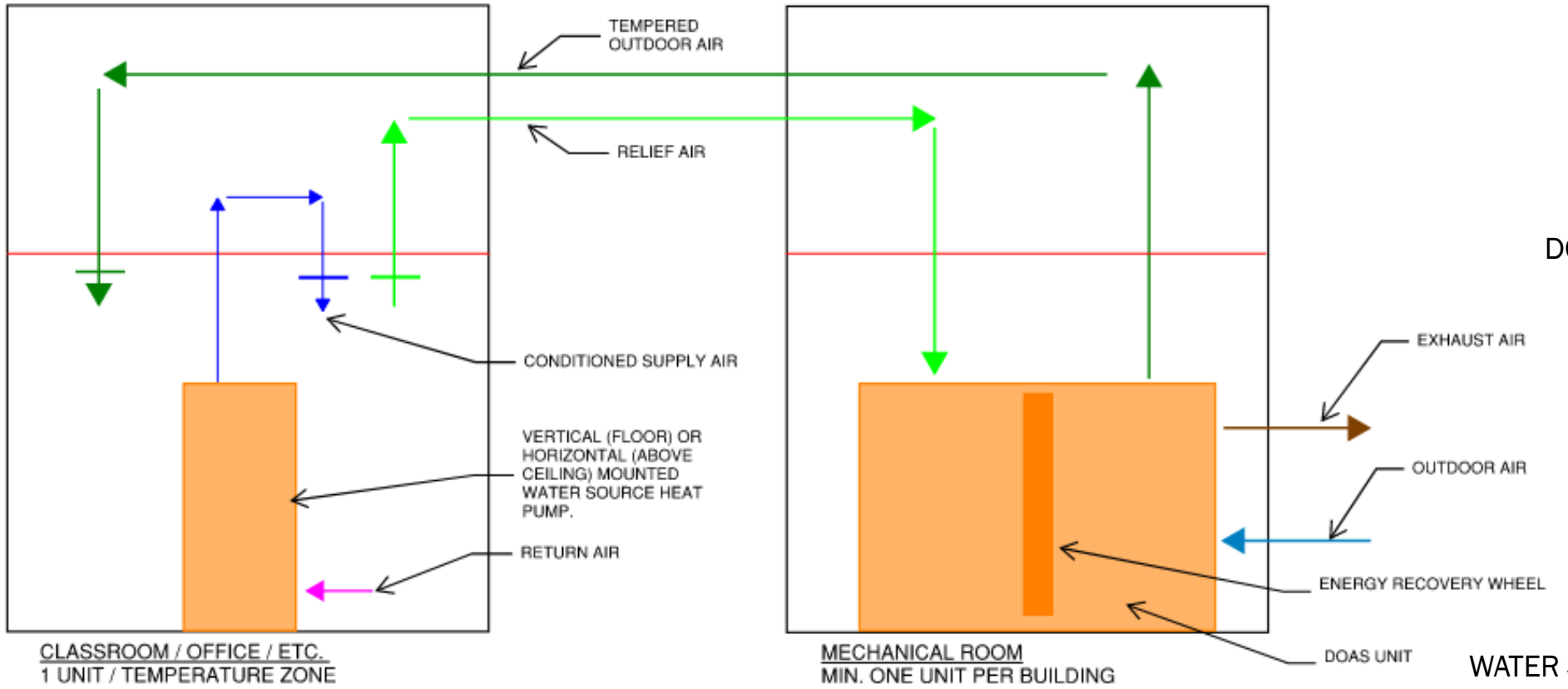
Geothermal Manifold

1. Supply/Return Header
2. Air/Dirt Separator
3. System Pumps
4. Expansion Tank

→ Direction of Flow

Geothermal System:

Air System Diagram - Classroom

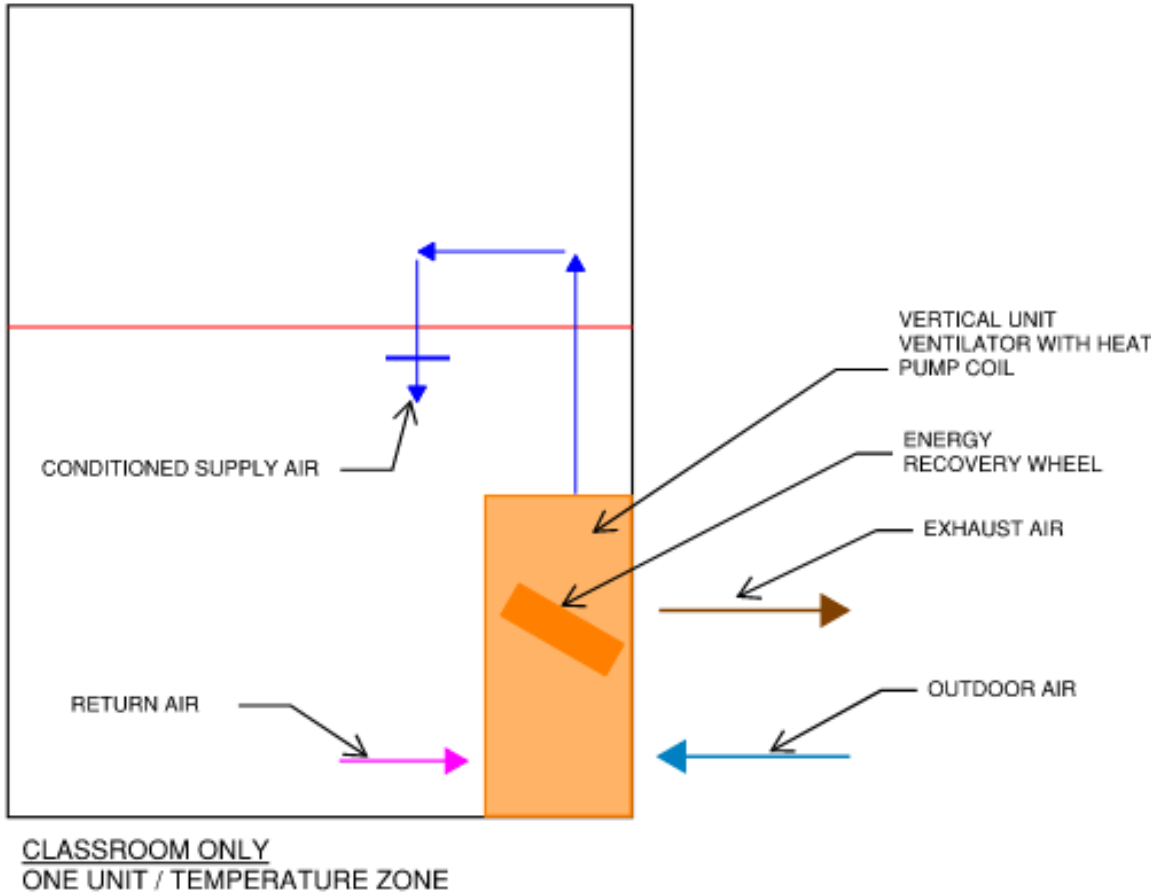


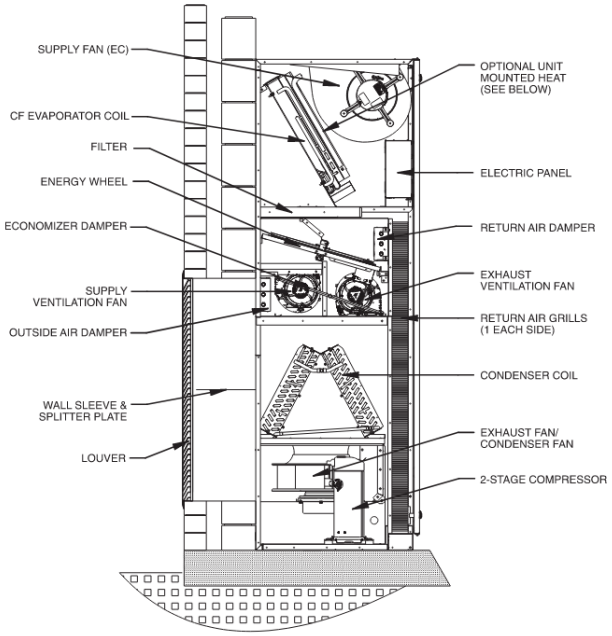
DOAS UNIT BY WATER FURNACE

WATER SOURCE HEAT PUMP BY WATER FURNACE

Geothermal System:

Air System Diagram - Classroom

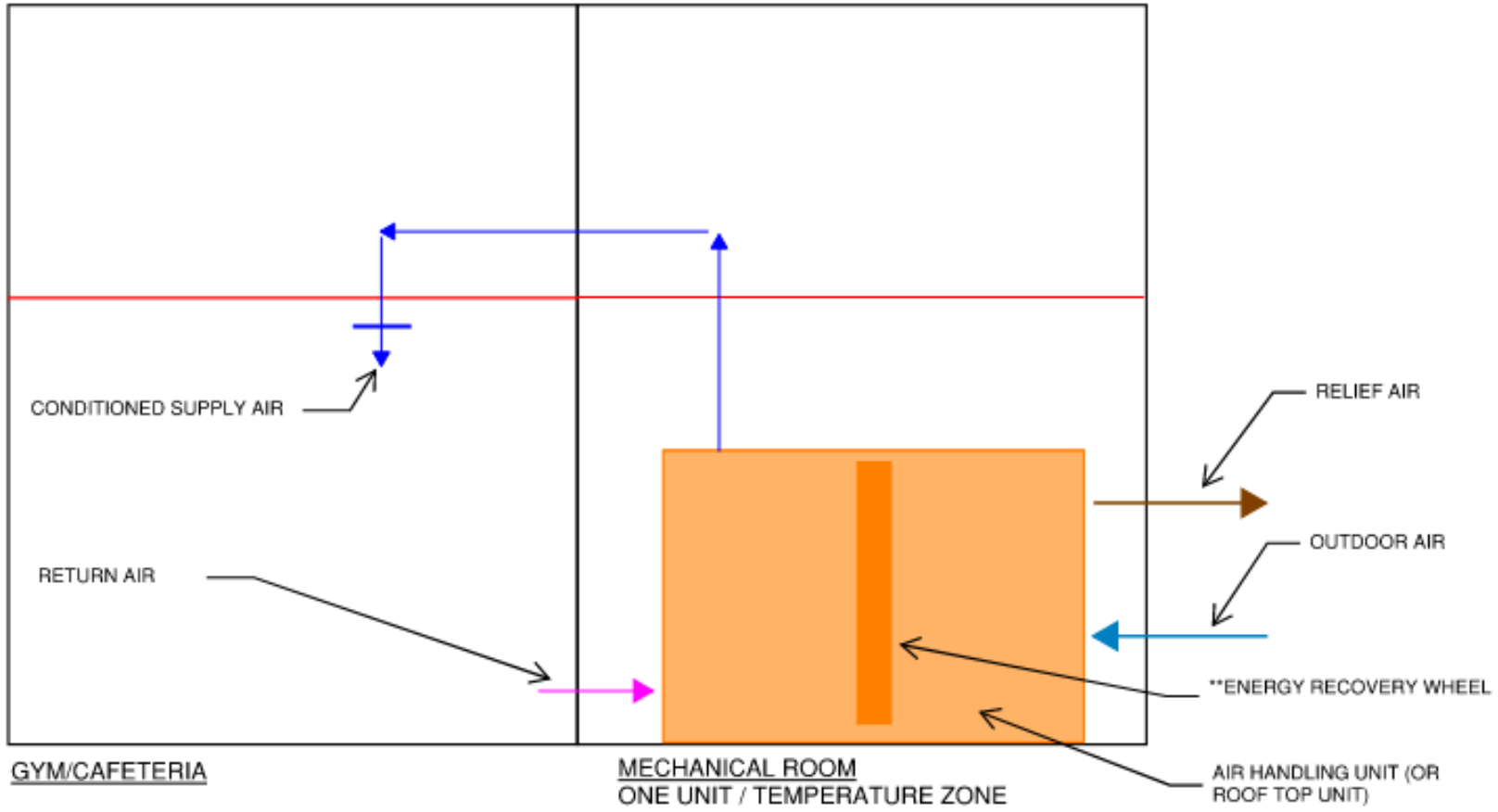




WATER SOURCE UNIT VENTLATOR BY AIREDALE

Geothermal System:

Air System Diagram – Large Space

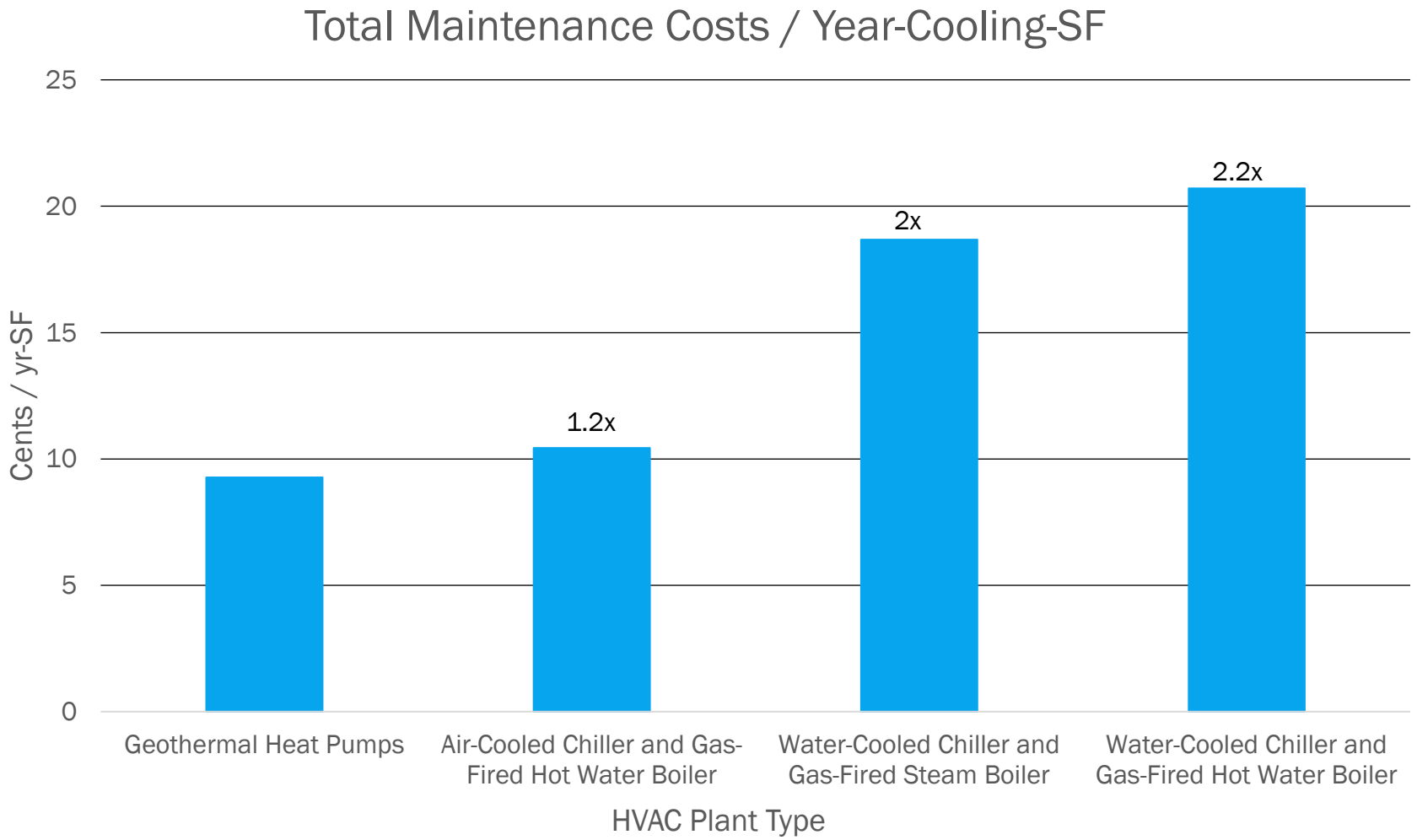


WATER SOURCE RTU BY WATER FURNACE

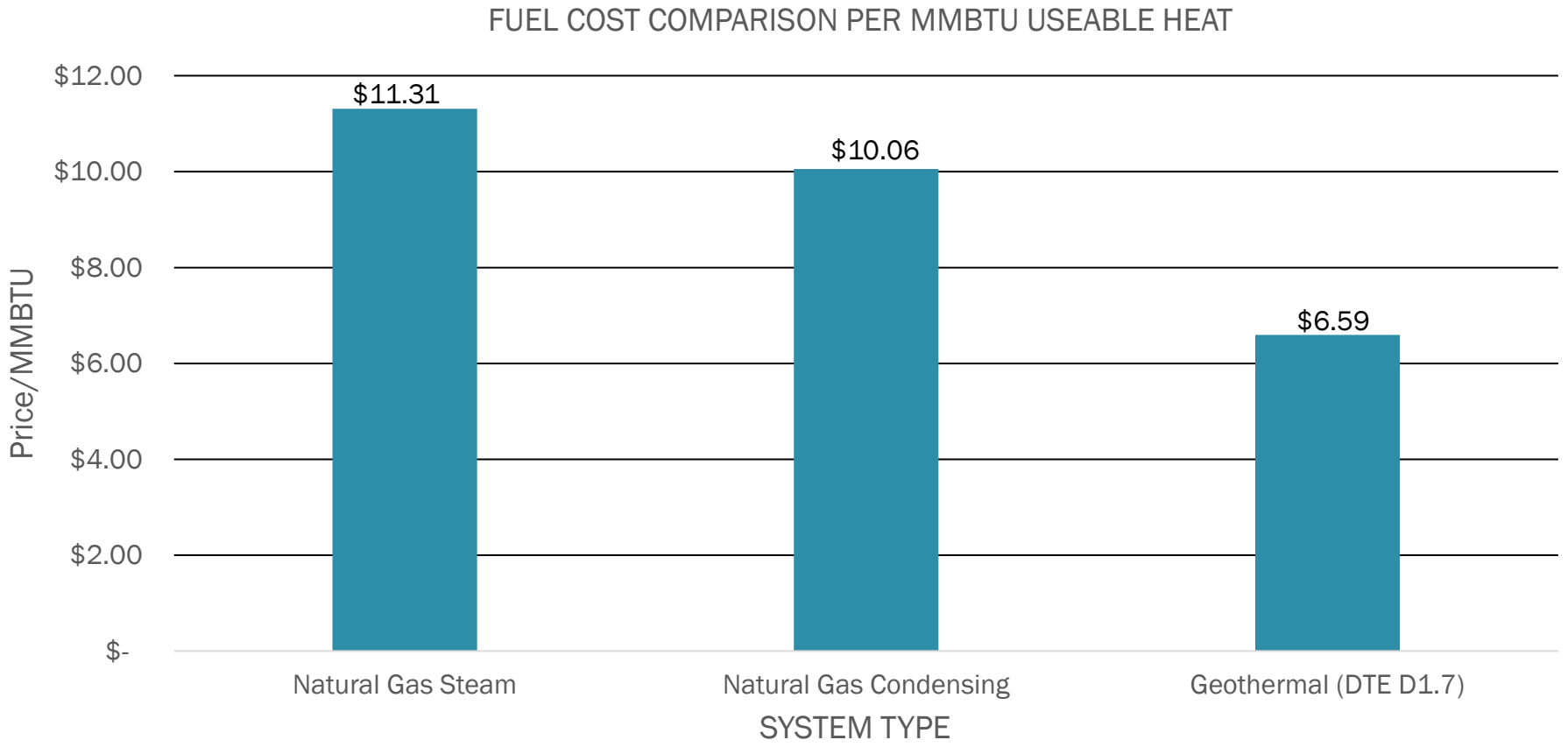
Geothermal Benefits:

- Per the US EPA, “geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective system for heating and cooling buildings.”
- Leads the way for electrification and decarbonization of the United States
- No on-site combustion of fossil fuels
- High heating efficiency
- STEM education opportunities
- Lowest average maintenance cost
- Political capital
- Marketing and branding opportunities
- HDPE piping has a standard 50-year warranty!
- Scalable for any project
  - SES Office
  - University of Michigan
  - Oakland University
  - Michigan State Capitol Building

Geothermal Benefits:



Geothermal Benefits:



System Type	Units	Unit Price	BTU/Unit	Efficiency / COP	Price/MMBTU
Electric Resistance	Kwh	$ 0.15	3,413	100%	$ 43.95
Natural Gas Steam	Therm	$ 0.91	100,000	80%	$ 11.31
Natural Gas Condensing	Therm	$ 0.91	100,000	90%	$ 10.06
Geothermal (DTE D1.7)	Kwh	$ 0.09	3,413	4.0	$ 6.59

Cost Impacts:

$

Inflation Reduction Act (IRA) of 2022

- Allows, for the first time, direct rebate equal to the total credit for non-taxable entities.
  - Nonprofit, state and local government, schools, tribes, and electrical cooperatives
  - Placed in service after 12/31/2022
- Section 48 of the US Tax Code:
  - " 'energy property' means as property which is .... Equipment which uses the ground or ground water as a thermal energy source to heat a structure or as a thermal energy sink to cool a structure, only with respect to property construction of which begins before January 1, 2035."

Base Credit: 30%
- 6% base rate with a 5x bonus

\+ Domestic Content Credit: 10%
- 2% base rate with a 5x bonus

40% of Total Geothermal System

- Equipment
- Borefield
- Design Fees
- CM Fees
- Electrical Costs
- Plumbing Costs

Tax Free Bond Funds → 34% Total

Cost Impacts:

$

DTE Rate Schedule No. D1.7: Geothermal Time-of-Day Rate

M.P.S.C. No. 1 - Electric
DTE Electric Company
(Final Order Case No. U-20836)

Fourth Revised Sheet No. D-13.01
Cancels Third Revised Sheet No. D-13.01

(Continued from Sheet No. D-13.00)

RATE SCHEDULE NO. D1.7 (Contd.) **GEOTHERMAL TIME-OF-DAY RATE**

Commercial Power Supply Charges:

Capacity Energy Charge (June through September):
3.370¢ per kWh for all On-peak kWh
1.752¢ per kWh for all Off-peak kWh

Capacity Energy Charge (October through May):
2.157¢ per kWh for all On-peak kWh
2.157¢ per kWh for all Off-peak kWh

On-Peak Hours: All kWh used between 1100 and 1900 hours Monday through Friday.
Off-Peak Hours: All other kWh used.

Non-Capacity energy Charge: ***2.346¢*** per kWh for all kWh

Commercial Delivery Charges:

Service Charge: 6.70¢ per day
Distribution Charge: ***3.848¢*** per kWh for all kWh

Surcharges and Credits: As approved by the Commission. See Sections C8.5 and C9.8.

Case Study:

Location: Detroit Area (Climate Zone 5A)

Building

- School 1: 40,000 SF K-5 Elementary
- School 2: 60,000 SF K-5 Elementary

System Type

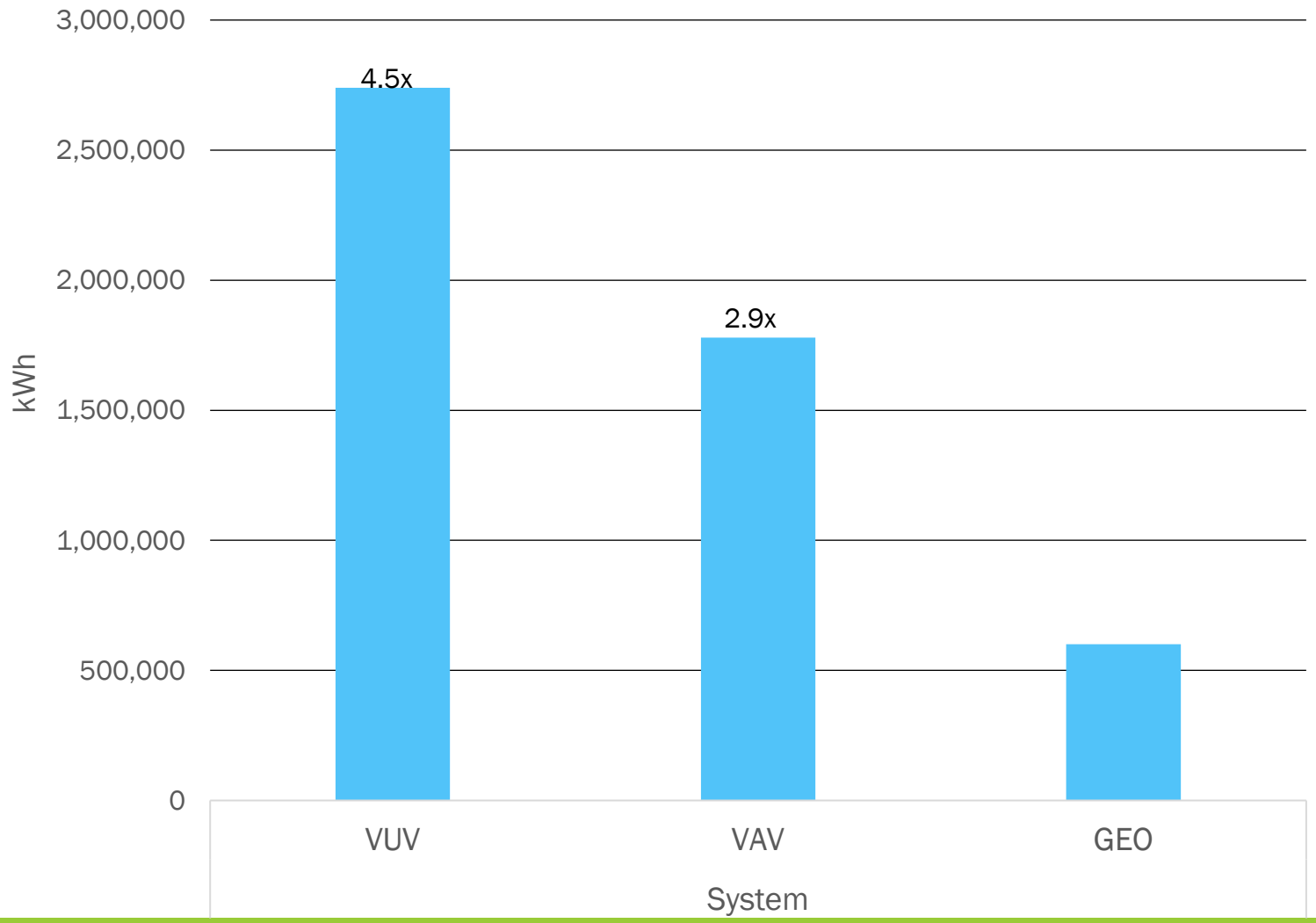
- Option 1: Unit Ventilators with DX-Cooling and HHW
- Option 2: Unit Ventilators with CHW and HHW
- Option 3: RTU with DX-Cooling, Gas Heat, and VAV with HHW Reheat
- Option 4: AHU with CHW Cooling, Gas Heat, and VAV with HHW Reheat
- Option 5: All Heat Pump with DOAS

Utility Provider Options

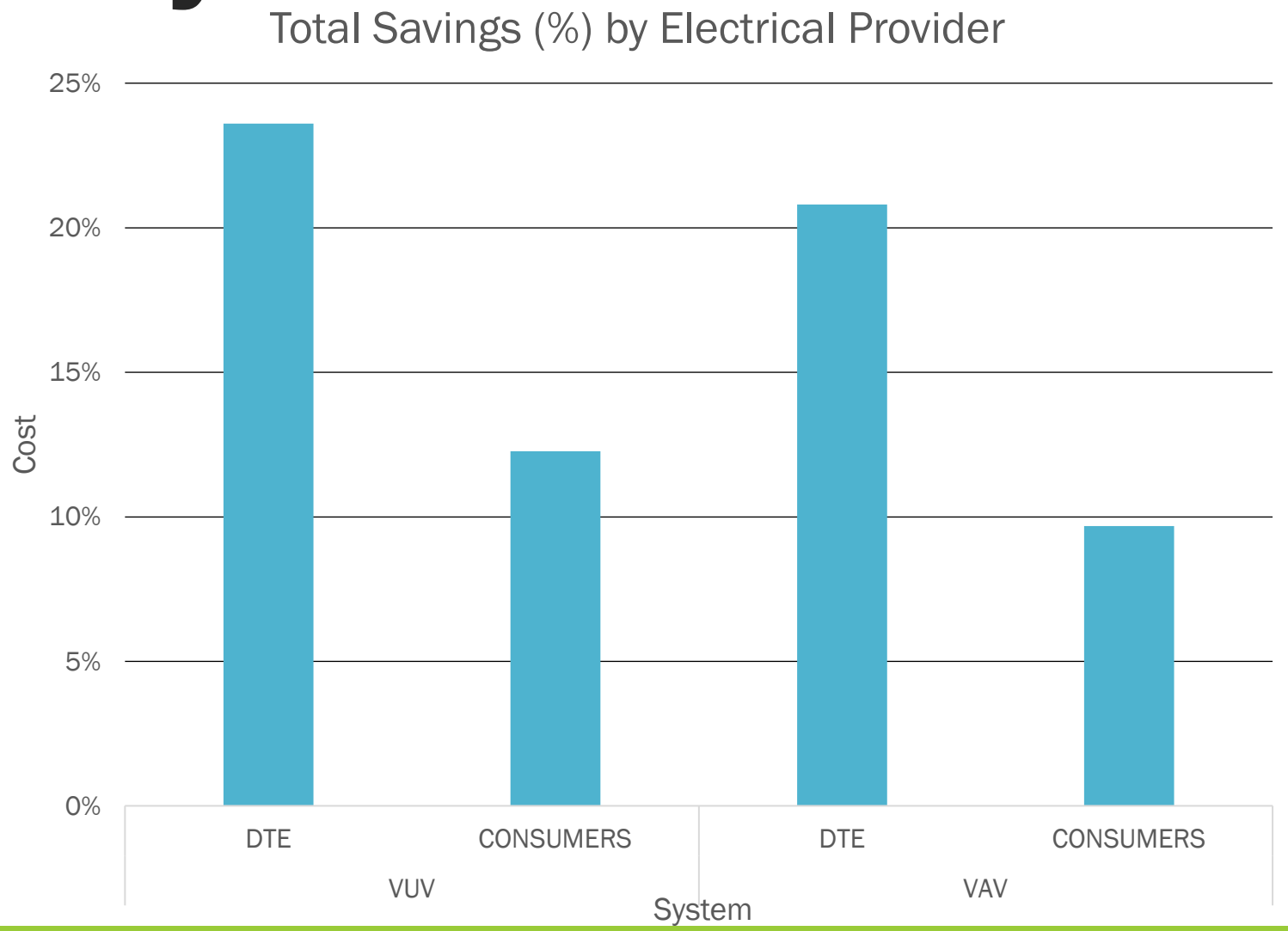
Electric	DTE	DTE	Consumers Energy	Consumers Energy
Gas	Consumers Energy	DTE	DTE	Consumers Energy

Case Study:

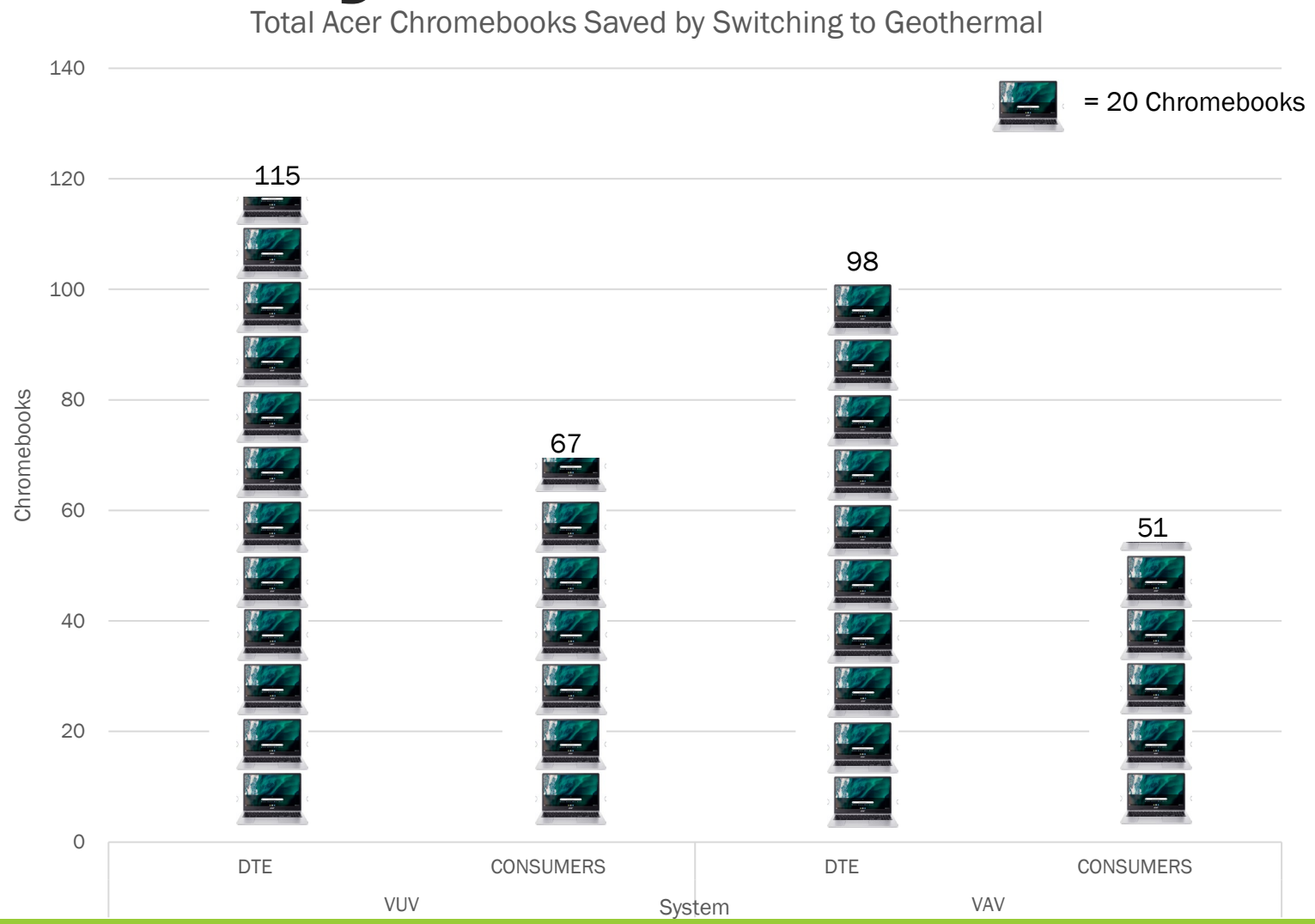
Case Study:


Total Energy By System Type
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
kWh
4.5x
2.9x
VUV
VAV
GEO
System

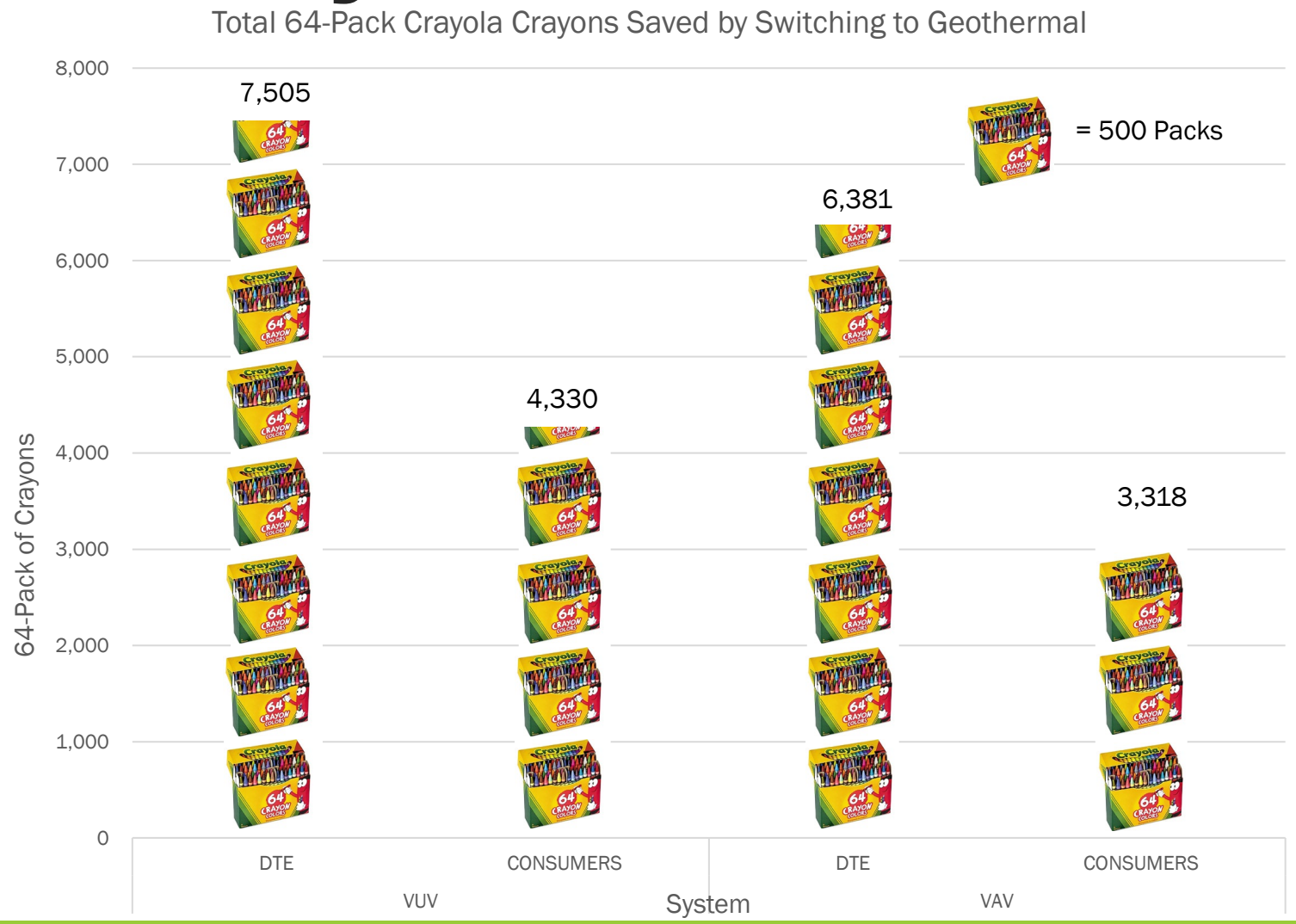
Case Study:


Total Savings (%) by Electrical Provider
25%
20%
15%
10%
5%
0%
Cost
DTE
CONSUMERS
DTE
CONSUMERS
VUV
VAV
System

Case Study:

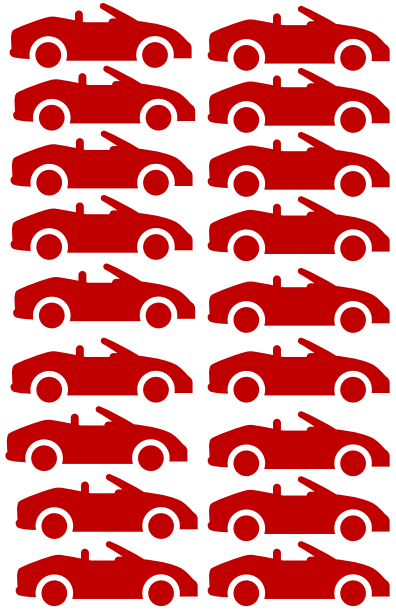

Total Acer Chromebooks Saved by Switching to Geothermal
= 20 Chromebooks
Chromebooks
140
120
100
80
60
40
20
0
115
67
98
51
DTE
CONSUMERS
DTE
CONSUMERS
VUV
VAV
System

Case Study:


Total 64-Pack Crayola Crayons Saved by Switching to Geothermal
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
64-Pack of Crayons
7,505
4,330
6,381
3,318
= 500 Packs
DTE
CONSUMERS
DTE
CONSUMERS
VUV
VAV
System

Case Study:

Average CO_2 Reduction: 176,000 lbs/year



18 Cars per Year

8x Around the Earth per Year

Case Study:

Geothermal HVAC Economics

Project Name: **Example School Building**

Conditioned Area: **48,300** sq. ft. Vertical Market: **K-12 Education** State: **Michigan**

Diversified Peak Load Density **400** sq. ft. per ton

Calculated HVAC tons: 121 Brief description of space: **one story building** Business Type: **Non-Taxable Entities**

Geothermal Costs			vs.	Conventional Costs		
Geothermal HVAC Cost	**$74.00**	per sq ft		Conventional HVAC Cost	**$58.00**	per sq ft
	$29,539	per ton			$23,152	per ton
	$ 3,574,200	Total Geothermal HVAC Cost			$ 2,801,400	Total Conventional HVAC Cost
	$ 689,700	Portion of Geothermal Cost Related to GHX				
	$ 14.28	Sq. Ft. Cost of GHX				
Describe your Geothermal System	distributed heat pumps			*Describe your Conventional HVAC System:*		

+ $772,800

Net **$0** per ton estimate of utility geo rebate

Other Installation Costs**: **$ 125,000** portion of electrical, plumbing and GC/AE fees related to HVAC system (for either system)

Income Tax Rate: **0%** Corporate / Federal **0.00%** State **0.00%**

Energy Credit: **26%** Domestic Content Credit: **9%**

Energy Inflation: **3%**

Savings per sq ft **$0.25** in Energy & Maintenance

Annual Cost Savings $ 12,075 Calculated Project Completion Year **2023** Project Completion Quarter **1**

YEAR	Geothermal Depreciation Bonus	Geothermal Depreciation 5 Yr MACRS	Geothermal Depreciation Bonus	Geothermal Depreciation 5 Yr MACRS	Geothermal Savings Direct Pay	Geothermal Savings Depreciation	Geothermal Annual Cash Flow Tax Savings	Geothermal Annual Cash Flow O&M Savings	Geothermal Annual Cash Flow Total	Conventional System Cash Flow Depreciation	Conventional System Cash Flow Tax Savings	Geothermal Net Cash Flow Annual	Geothermal Net Cash Flow Cumulative
2023	80%	35.00%						$ 9,056	$ 493,984	0	$ -	$ 493,984	$ 493,984
2024		26.00%						$ 12,437	$ 12,437	0	$ -	$ 12,437	$ 506,422
2025		15.60%						$ 12,810	$ 12,810	0	$ -	$ 12,810	$ 519,232
2026		11.01%						$ 13,195	$ 13,195	0	$ -	$ 13,195	$ 532,427
2027		11.01%						$ 13,591	$ 13,591	0	$ -	$ 13,591	$ 546,017
2028		1.38%						$ 13,998	$ 13,998	0	$ -	$ 13,998	$ 560,015
2029								$ 14,418	$ 14,418	0	$ -	$ 14,418	$ 574,433
2030								$ 14,851	$ 14,851	0	$ -	$ 14,851	$ 589,284
2031								$ 15,296	$ 15,296	0	$ -	$ 15,296	$ 604,580
2032								$ 15,755	$ 15,755	0	$ -	$ 15,755	$ 620,336
2033								$ 16,228	$ 16,228	0	$ -	$ 16,228	$ 636,563

$1,257,728 Credit

VERTICAL UNIT VENT

CONVENTIONAL COST: $2,801,400

GEOTHERMAL COST: $2,316,472

SAVINGS: $484,928

PAY BACK: 0 YEARS

Case Study:

Geothermal HVAC Economics

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	$29,539	per ton			$25,946	per ton
	$ 3,574,200	Total Geothermal HVAC Cost			$ 3,139,500	Total Conventional HVAC Cost
	$ 689,700	Portion of Geothermal Cost Related to GHX				
	$ 14.28	Sq. Ft. Cost of GHX				
Describe your Geothermal System	distributed heat pumps			*Describe your Conventional HVAC System:*		

+ $434,700

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2023	80%	35.00%					(700)		$ 9,056	$ 832,084	0	$ -	$ 832,084	$ 832,084
2024		26.00%							$ 12,437	$ 12,437	0	$ -	$ 12,437	$ 844,522
2025		15.60%							$ 12,810	$ 12,810	0	$ -	$ 12,810	$ 857,332
2026		11.01%							$ 13,195	$ 13,195	0	$ -	$ 13,195	$ 870,527
2027		11.01%							$ 13,591	$ 13,591	0	$ -	$ 13,591	$ 884,117
2028		1.38%							$ 13,998	$ 13,998	0	$ -	$ 13,998	$ 898,115
2029									$ 14,418	$ 14,418	0	$ -	$ 14,418	$ 912,533
2030									$ 14,851	$ 14,851	0	$ -	$ 14,851	$ 927,384
2031									$ 15,296	$ 15,296	0	$ -	$ 15,296	$ 942,680
2032									$ 15,755	$ 15,755	0	$ -	$ 15,755	$ 958,436
2033									$ 16,228	$ 16,228	0	$ -	$ 16,228	$ 974,663

$1,257,728 Credit

VAV W/ REHEAT SYSTEM

CONVENTIONAL COST: $3,193,500

GEOTHERMAL COST: $2,316,472

SAVINGS: $823,028

PAY BACK: 0 YEARS

What to Look For:

Design Team

- How long has the firm been designing geothermal systems?
- How many projects have they successfully completed?
- Have they done any projects similar to yours in terms of size and scope?
- Are they knowledgeable and able to help you during bidding and contractor selection?
- Can they identify issues and offer solutions?
- Do they have strong connections within the geothermal community?
- Are they certified?
  - Certified Geothermal Designer
  - Certified Geothermal Installer
  - Certified Geothermal Inspector

https://igshpa.org/directory-landing/

What to Look For:

Drawings

- Schedule for the ground heat exchanger
  - Number of Bores
  - Bore Depth
  - Bore Pipe Size
  - Soil Diffusivity and Conductivity
  - Pressure Drop
  - Fluid Type, Flow, and Temperatures
  - Grout Type and Conductivity
  - Flush and Purge Information
  - Capacity
- Drill Log
  - Indicates the type of soil conditions at different depths

DRILL LOG FROM FTC TEST	
FORMATION DESCRIPTION	DEPTH
GRAVEL / CLAY	0' – 120'
CLAY	120' – 150'
GRAVEL	150' – 151'
CLAY	151' – 170'
CLAY	170' – 175'
HARD CLAY / SMALL GRAVEL	175' – 240'
GRAVEL / BROKEN LIMESTONE	240' – 260'
GREY SHALE	260' – 450'
GREY / BLACK SHALE	450' – 470'
HARD GREY SHALE	470' – 520'
GREY SHALE / BLACK SHALE	520' – 550'
GREY / BLACK SHALE	550' – 600'
GREY SHALE	600' – 610'
BLACK SHALE	610' – 655'
GREY STICKY SHALE	655' – 680'
BLACK SHALE / GREY MIX	680' – 690'
BLACK SHALE	690' – 790'
GREY / BLACK SHALE MIX	790' – 830'
GREY SANDSTONE / BROWN GRANITE	830' – 840'
BLACK / GREY SHALE	840' – 845'
GREY SANDSTONE	845' – 850'

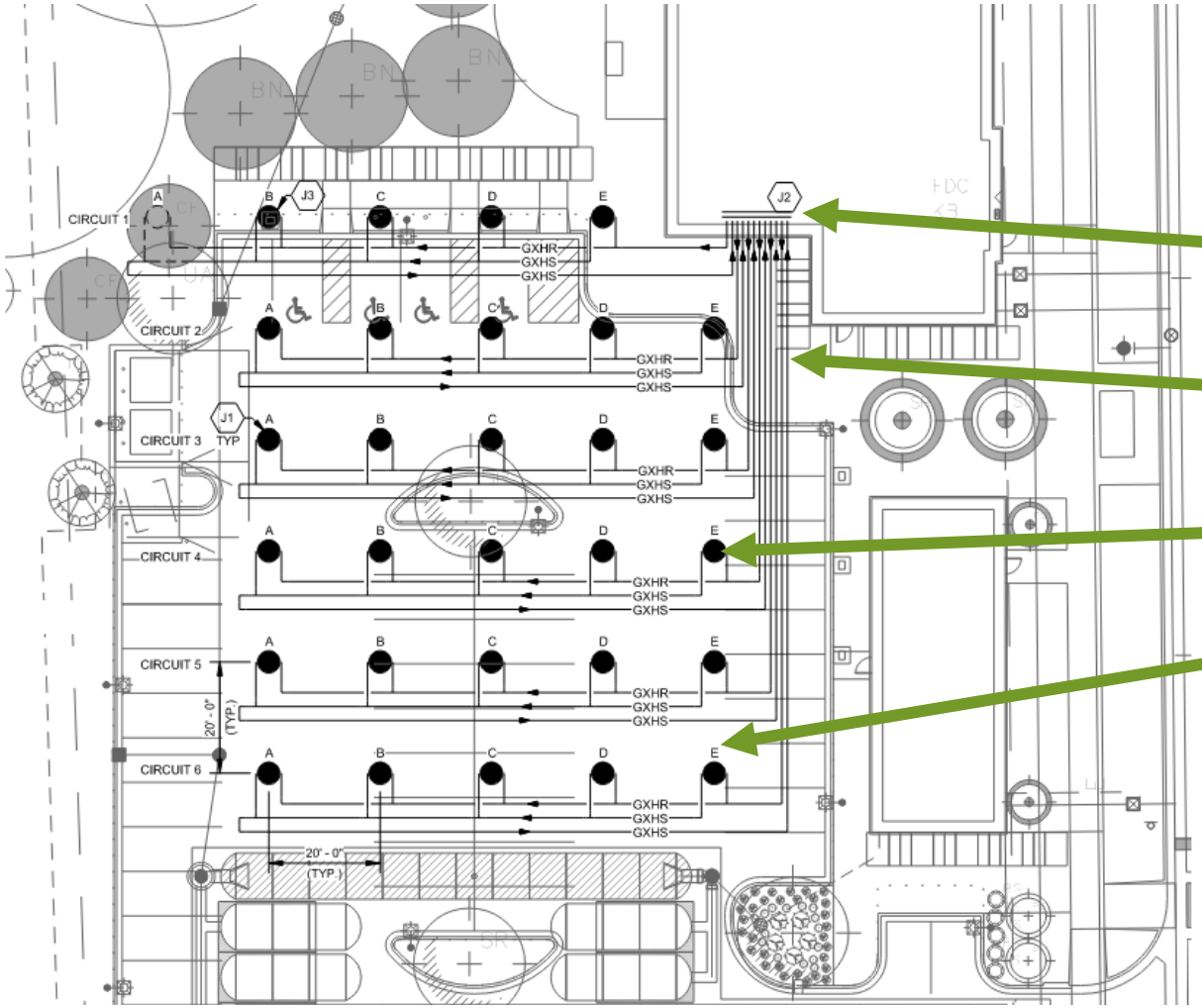
DATA BASED ON THERMAL CONDUCTIVITY TEST REPORT DATED OCTOBER 1, 2021.

GROUND HEAT EXCHANGER SUMMARY INFORMATION	
HEAT EXCHANGER INFORMATION	
CONFIGURATION	VERTICAL CLOSED LOOP
BOREHOLE QUANTITY	99 (INCLUSIVE OF 1 TEST BORE)
BOREHOLE PIPE SIZE	1 1/2 INCH
BOREHOLE ACTIVE DEPTH	700' (TYPICAL FOR 99)
BOREHOLE TOTAL DEPTH	705' (TYPICAL FOR 99)
BOREHOLE SEPARATION	20 FT ON CENTER
NUMBER OF CIRCUITS	9
FUTURE CIRCUIT SUPPLY AND RETURNS	7
* SOIL THERMAL CONDUCTIVITY	1.61 BTU/(H*FT*F)
* SOIL DIFFUSIVITY	1.20 FT^2/DAY
* UNDISTURBED GROUND TEMPERATURE	54.5 °F
GHX PRESSURE DROP	40.0 FT HD
SYSTEM FLUID INFORMATION	
TOTAL FLOW	990 GPM
FLUID	WATER
** GHX VOLUME	15,280 GALLONS
MINIMUM HEAT PUMP INLET FLUID TEMP	54.5 °F
MAXIMUM HEAT PUMP INLET FLUID TEMP	90 °F
GROUT INFORMATION	
GROUT TYPE	BENTONITE WITH GRAPHITE BASED THERMAL ENHANCEMENT COMPOUND
MINIMUM THERMAL CONDUCTIVITY	1.20 BTU/H-FT-°F
FLUSH & PURGE INFORMATION	
MINIMUM FLUID VELOCITY	2.0 FT/SEC
MINIMUM PURGE FLOW (PER CIRCUIT)	132 GPM
PURGE PRESSURE DROP (PER CIRCUIT)	39.4 FT HD
GHX CAPACITY INFORMATION	
PEAK HEATING	1,920 MBH
PEAK COOLING	3,900 MBH
HEATING EFLH	1,200 HOURS
COOLING EFLH	1,300 HOURS

* DATA BASED ON THERMAL CONDUCTIVITY TEST REPORT DATED OCTOBER 1, 2021.

** GHX TOTAL VOLUME TO BE CALCULATED BY GEOTHERMAL CONTRACTOR BASED ON AS-BUILT CONFIGURATION.

What to Look For:



GEOTHERMAL KEYNOTES

J1 VERTICAL GEOTHERMAL BOREHOLE. TYPICAL FOR 30. REFER TO SUMMARY TABLE FOR ADDITIONAL INFORMATION. SIZE OF BOREHOLE IS DIAGRAMMATIC IN SCALE. TYPICAL BORE HOLE DIAMETER IS 6".

J2 GEOTHERMAL MANIFOLD CONSISTING OF SUPPLY/RETURN HEADER PIPING LOCATED IN BASEMENT MECHANICAL ROOM. REFER TO PIPING DETAIL ON SHEET GHX5.0.

J3 COORDINATE GEOTHERMAL BORE AND PIPING WITH STORM SEWER. MAINTAIN MIN 3'-0" SEPARATION BETWEEN VERTICAL BORE AND STORM UTILITY PIPING.

GEOTHERMAL MANIFOLD

SUPPLY AND RETURN HEADER PIPING

TYPICAL BORE HOLE

BORE HOLE IDENTIFIER

Summary:

WHO: You and a carefully selected design team

WHAT: Geothermal HVAC Systems

WHEN: Right Now (IRA is currently active through 2032)

WHERE: Anywhere – more specifically, your district

WHY: Reduce overall energy, save money, reduce your carbon footprint


DIG DEEP & SAVE MONEY
with
GEOTHERMAL

Questions

Comments

Discussion

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