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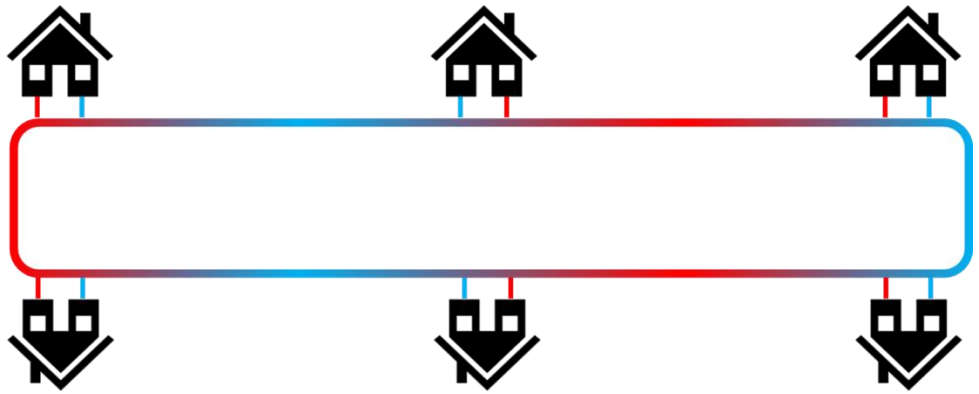


Introduction to Ground Source Heat Pumps

Connor Dacquay, Dr. Eng, PE, CGD

Heat Transfer

- Conduction
- Convection
- Radiation

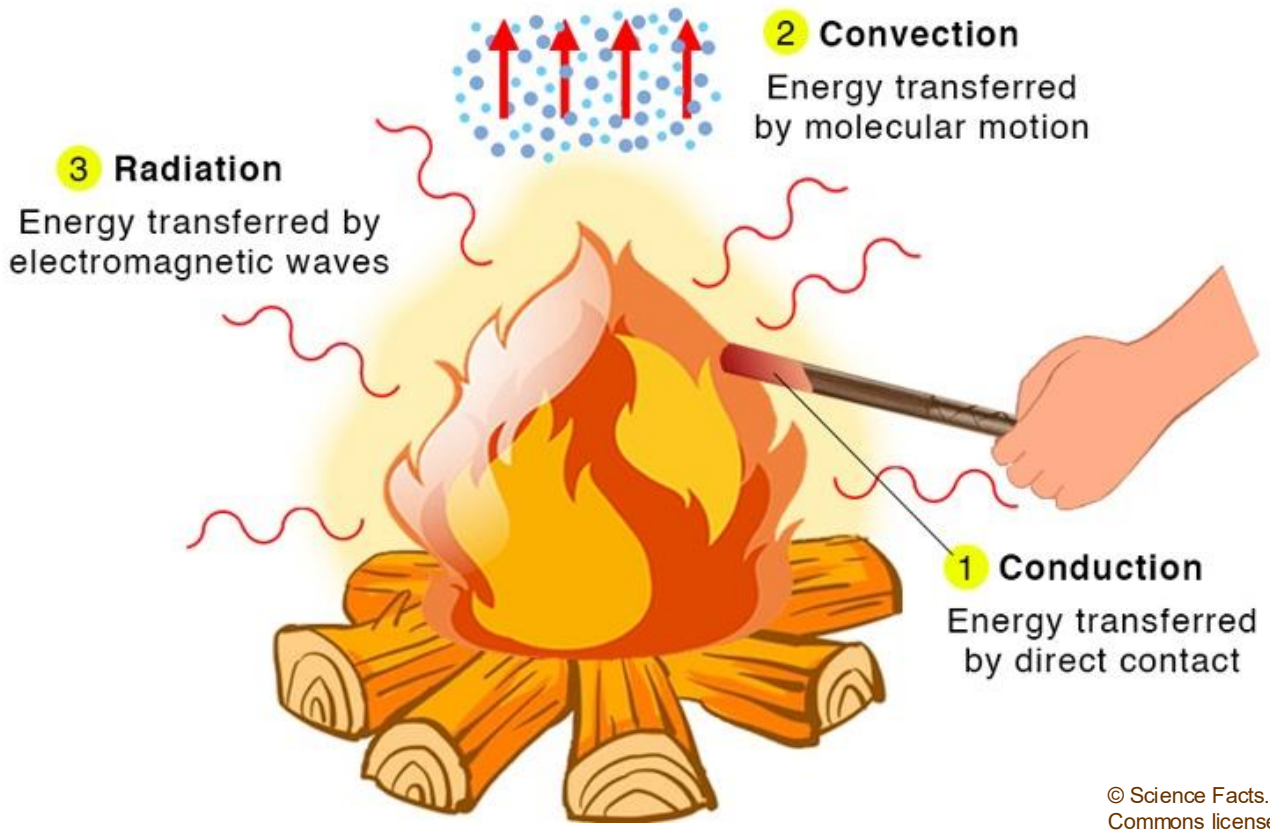


Image credit https://www.sciencefacts.net/heat-transfer.html

Conduction

- When heat is directly transmitted through a substance when there is a difference of temperature.

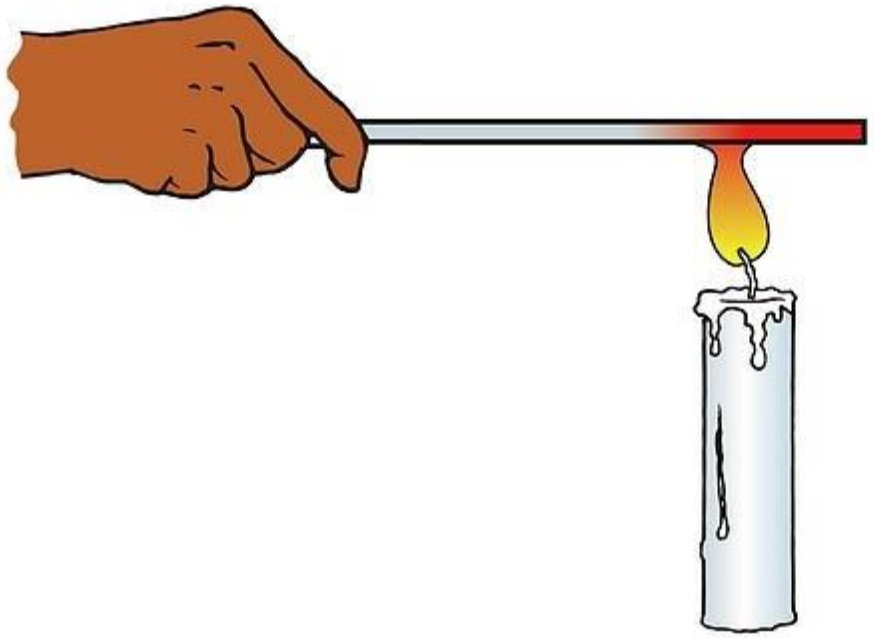
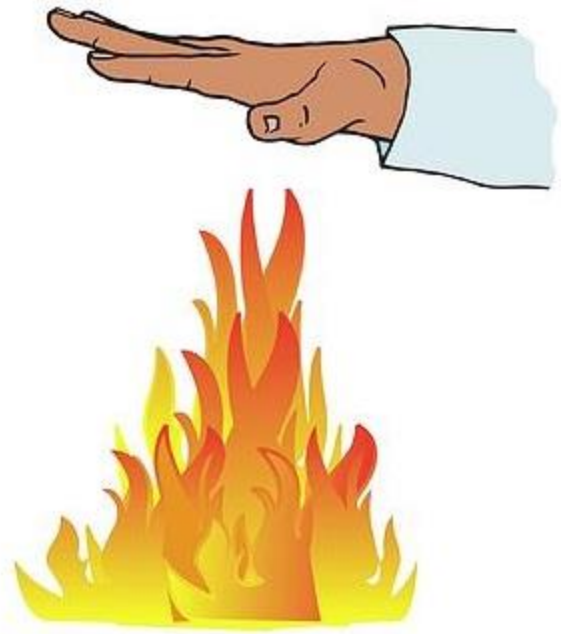


Image credit https://sciencephotogallery.com/featured/2-conduction-science-photo-library.html

Convection

- The rising motion of warmer areas of a liquid or gas, and the sinking motion of cooler areas of liquid or gas.



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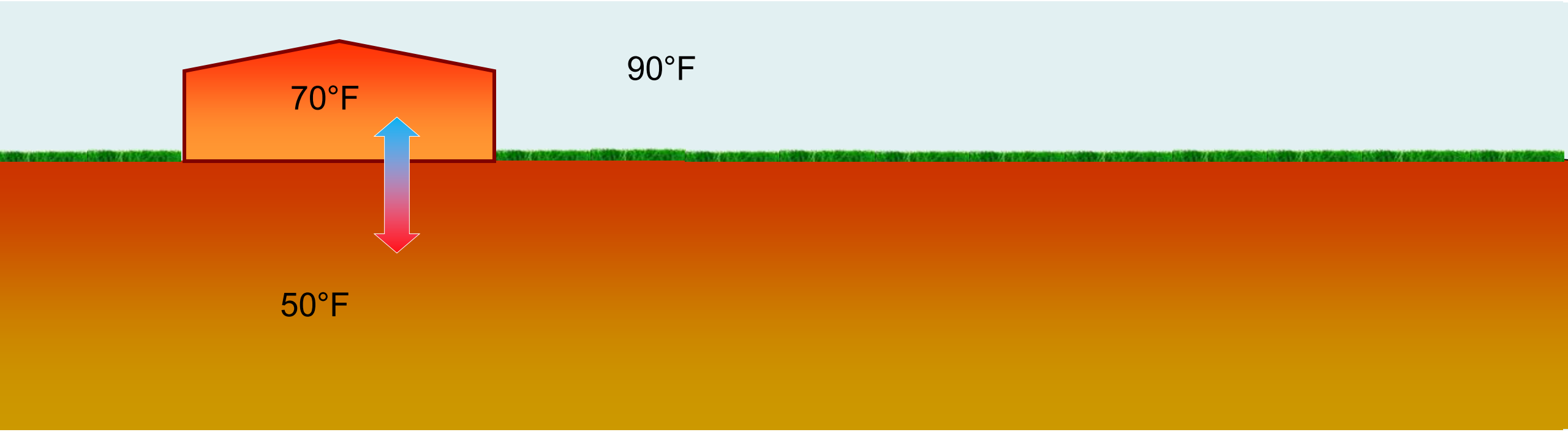
Radiation

- The process where heat energy is transferred from one object to another through the emission of electromagnetic waves.

Image credit https://depositphotos.com/vectors/convection-heat.html

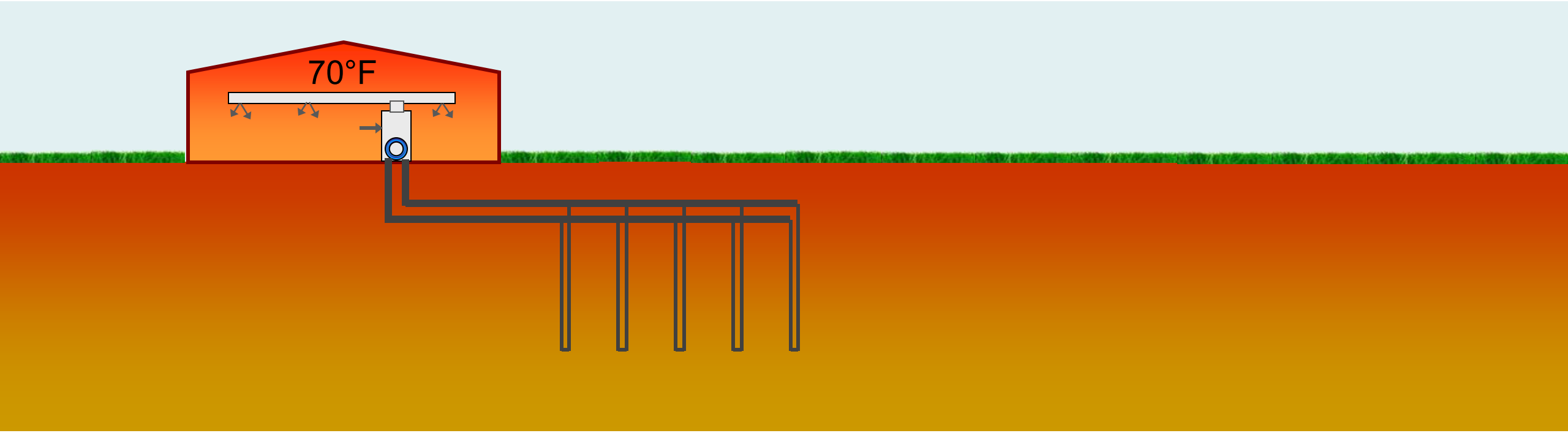
Earth Energy Resource

- Geo: relating to the earth
- Thermal: relating to heat



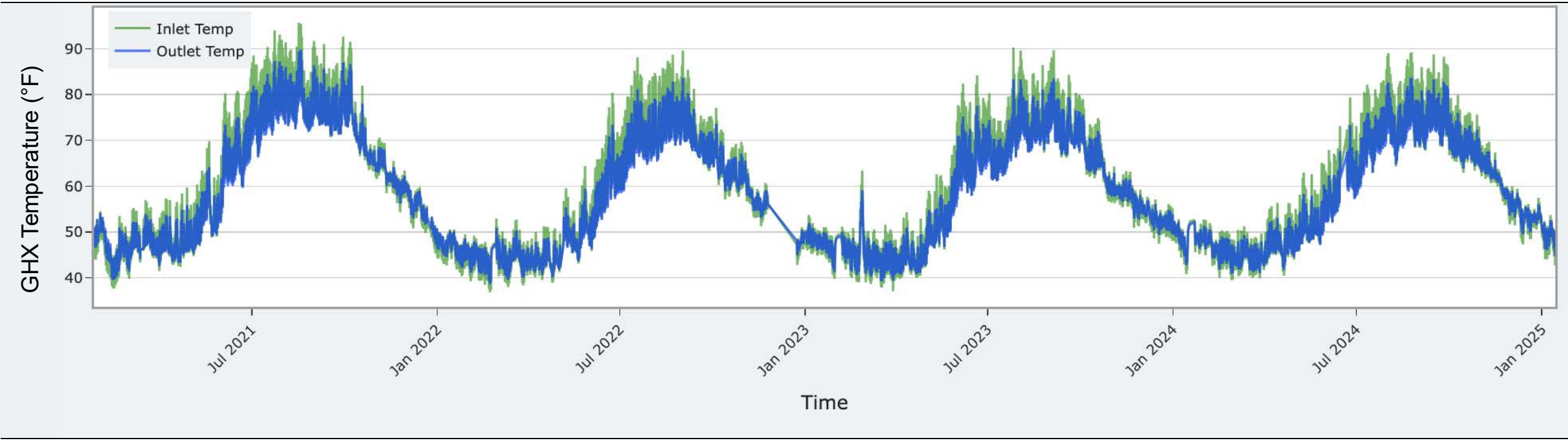
Earth Energy Resource

- Plastic pipe transfers heat to volume of earth
- Heat exchange fluid is pumped through the pipe
- Pipe is connected to a heat pump

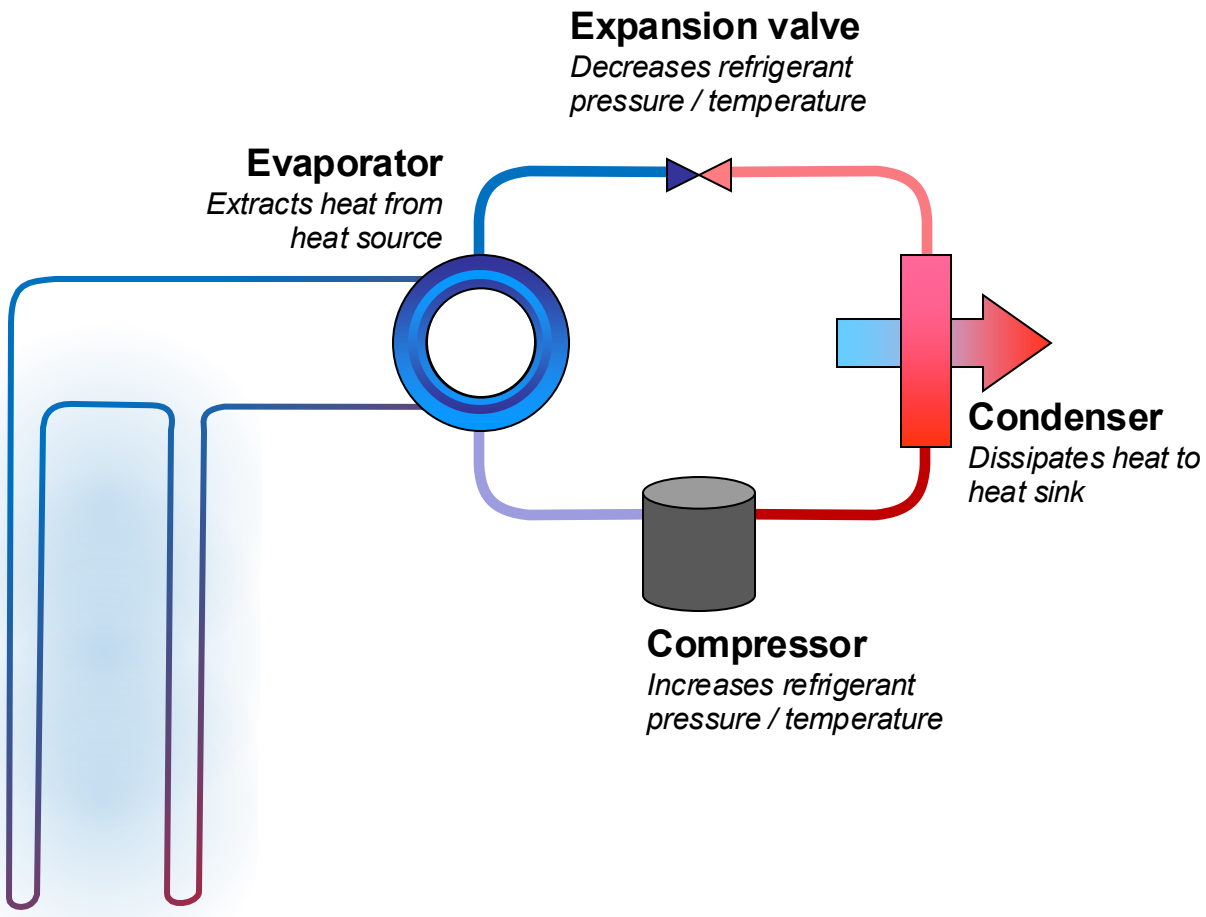


Earth Energy Resource

- Ground heat exchanger (GHX) typically designed to deliver fluid temperatures to heat pumps between 30 and 90°F
- Horizontal GHX temperature data over 4 years shows stable temperatures

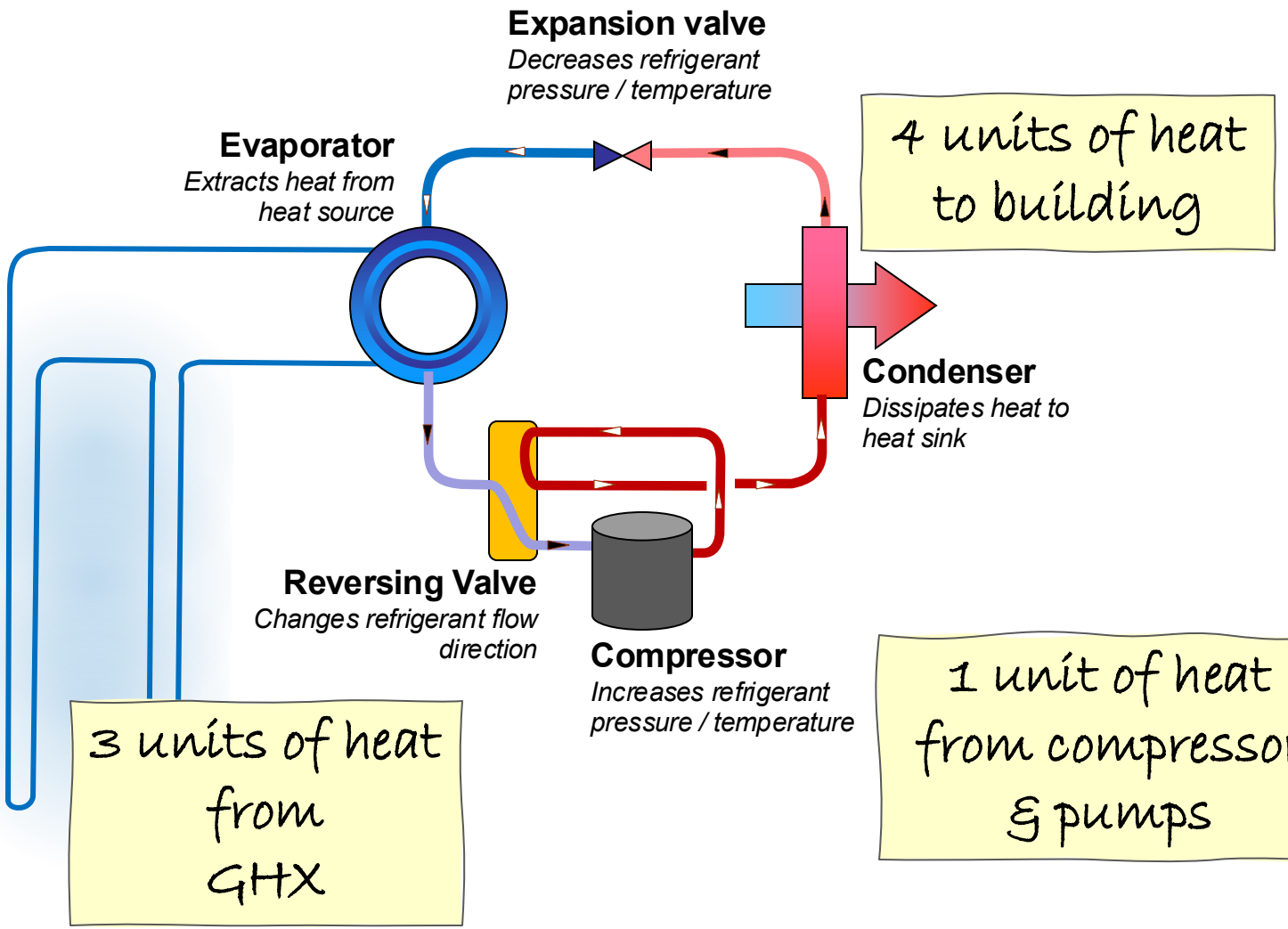


Heat Pump Components



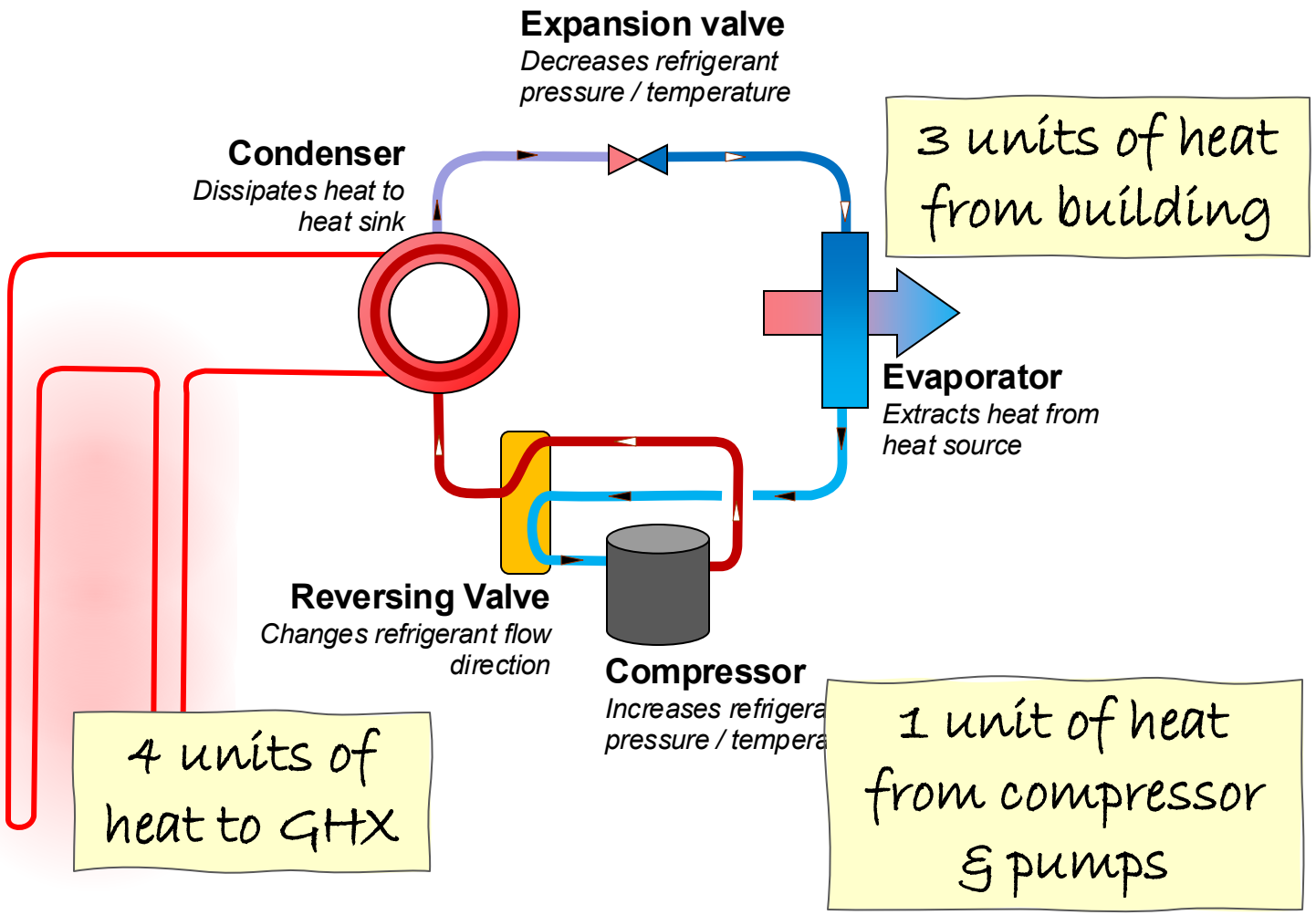
- Evaporator: transfers heat with external environment (air, ground, water)
- Compressor: compresses refrigerant, increasing pressure and temperature
- Condenser: condenses refrigerant vapor into liquid, phase change transfers large amount of heat
- Expansion valve: reduces pressure / temperature to prepare for heat transfer

Heat Pump Components - Heating



- Heat is extracted from GHX
- Compressor uses electricity to compress and heat refrigerant
- Hot refrigerant pushed through condenser, rejects heat to air in building

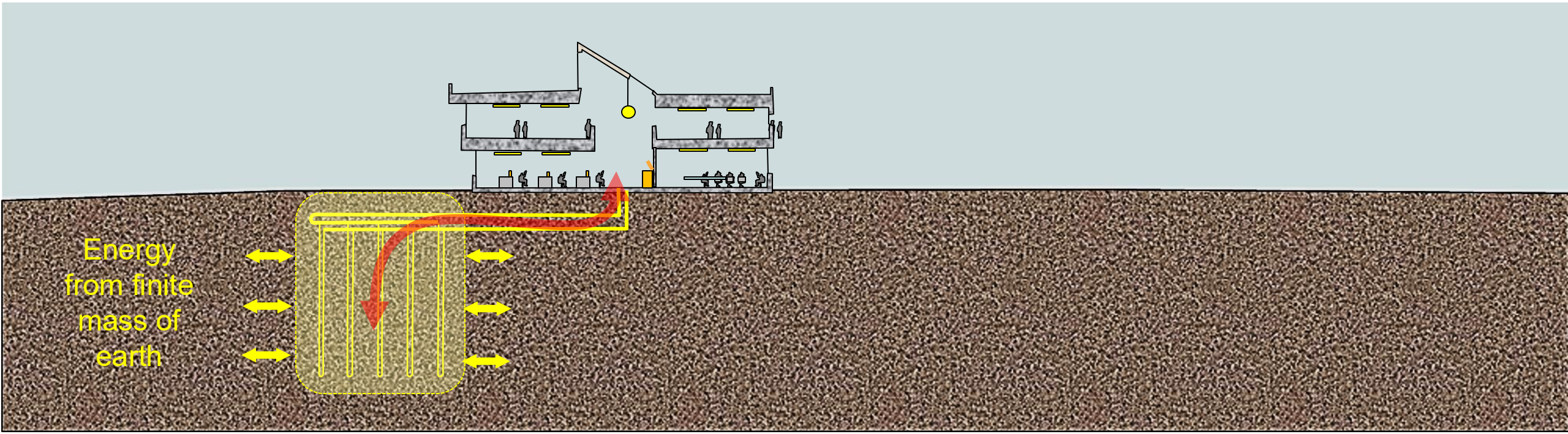
Heat Pump Components - Cooling



- Heat extracted from air in building, vaporizing refrigerant
- Compressor compresses and heats refrigerant
- Hot refrigerant pushed through condenser, rejects heat to fluid in GHX

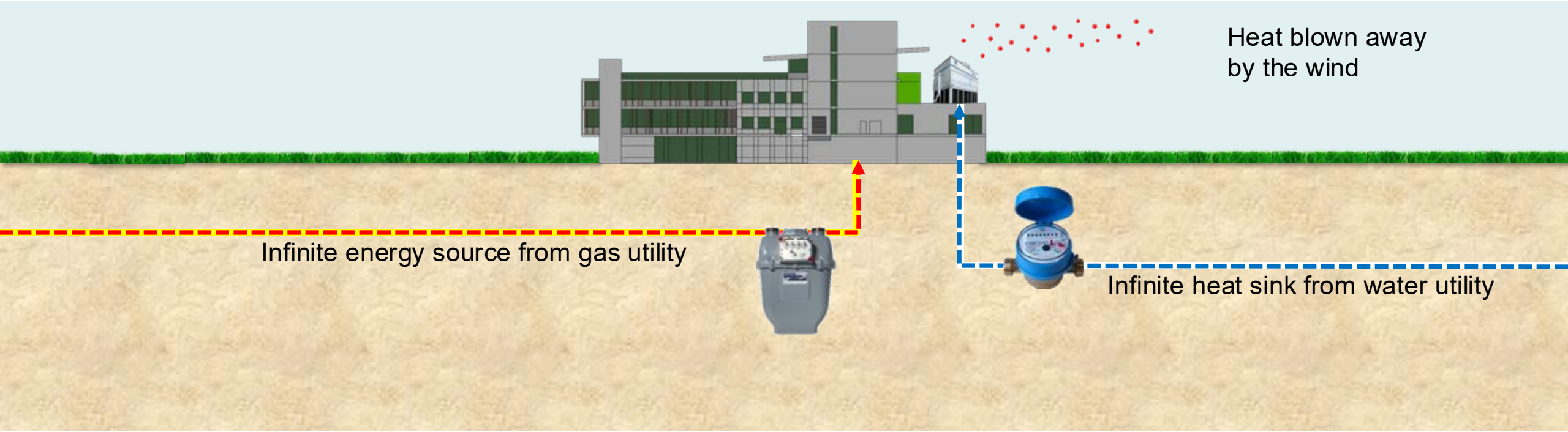
Earth Energy Resource Engineering

- GSHP systems require analysis of total ‘demand’ to determine ‘supply’
- Conventional HVAC system does not consider total annual heating and cooling loads
- The gas line and cooling tower are sized on peak loads



Conventional HVAC System Design

- Pipeline large enough to meet peak heating load on the coldest day
- Cooling tower dissipates heat by evaporating water
- Energy is available if utility is paid



Peak Loads vs. Total Loads

- Church, retail store and apartment
- Peak cooling loads are identical – 480 kBtu/hr (40 tons)
- Peak heating loads are identical – 385 kBtu/hr (385 MBH)

Peak Loads vs. Total Loads

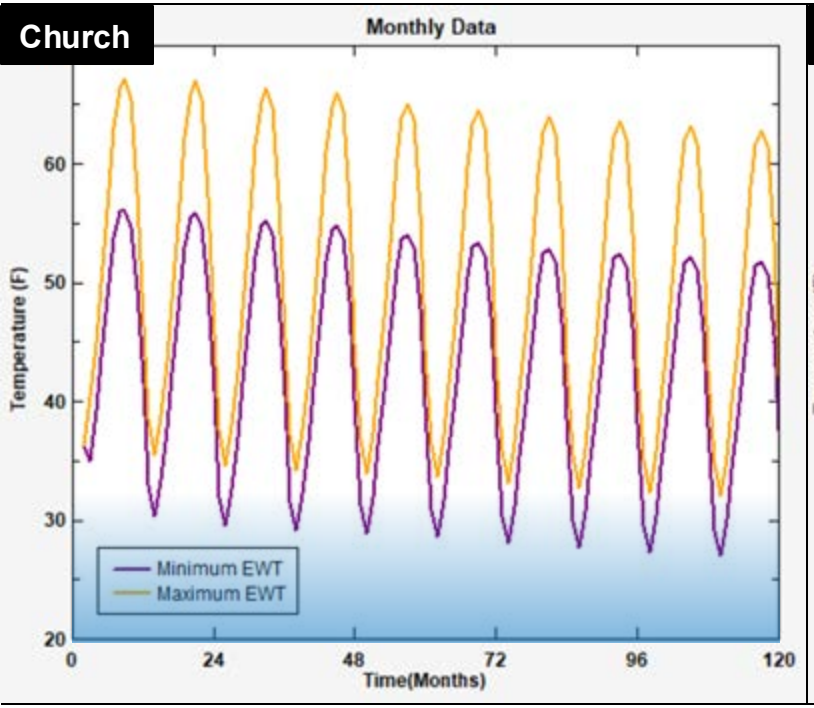
- Different occupancy creates different annual total heating and cooling loads
- Heating / cooling ratio impacts sustainability of GHX

	Church					Retail					Apartment			
	Clg kBtu	Clg kBtu/hr	Htg kBtu	Htg kBtu/hr		Clg kBtu	Clg kBtu/hr	Htg kBtu	Htg kBtu/hr		Clg kBtu	Clg kBtu/hr	Htg kBtu	Htg kBtu/hr
Jan	3820	8	189734	**385**	Jan	19906	93	89734	**385**	Jan	5560	25	159734	**385**
Feb	6202	23	135120	366	Feb	28202	110	65120	346	Feb	7840	83	112120	360
Mar	12177	76	81304	312	Mar	30177	215	41304	240	Mar	14177	185	71304	305
Apr	16800	216	36614	170	Apr	40866	285	16614	110	Apr	28866	260	30614	155
May	24640	367	11152	65	May	53946	396	3152	35	May	43946	329	11152	60
Jun	46285	446	3180	5	Jun	82094	446	180	0	Jun	72094	423	8545	45
Jul	52680	**480**	886	0	Jul	102358	**480**	0	0	Jul	92358	**480**	7650	43
Aug	49068	465	1725	0	Aug	102393	439	125	0	Aug	78393	447	7550	45
Sep	38560	314	5479	53	Sep	89245	360	2379	26	Sep	59450	360	8479	53
Oct	13821	121	24702	137	Oct	63821	223	9702	128	Oct	19821	169	18702	132
Nov	7571	62	98784	298	Nov	41571	135	36784	251	Nov	8690	79	66784	269
Dec	4884	10	176775	348	Dec	27884	102	76775	331	Dec	6570	22	126775	340
	276508	**480**	**765455**	**385**		**682463**	**480**	**341869**	**385**		**437765**	**480**	**629409**	**385**
	Annual Cooling / Heating Ratio:			**2.8 to 1**		Annual Cooling / Heating Ratio:			**2.0 to 1**		Annual Cooling / Heating Ratio:			**0.7 to 1**

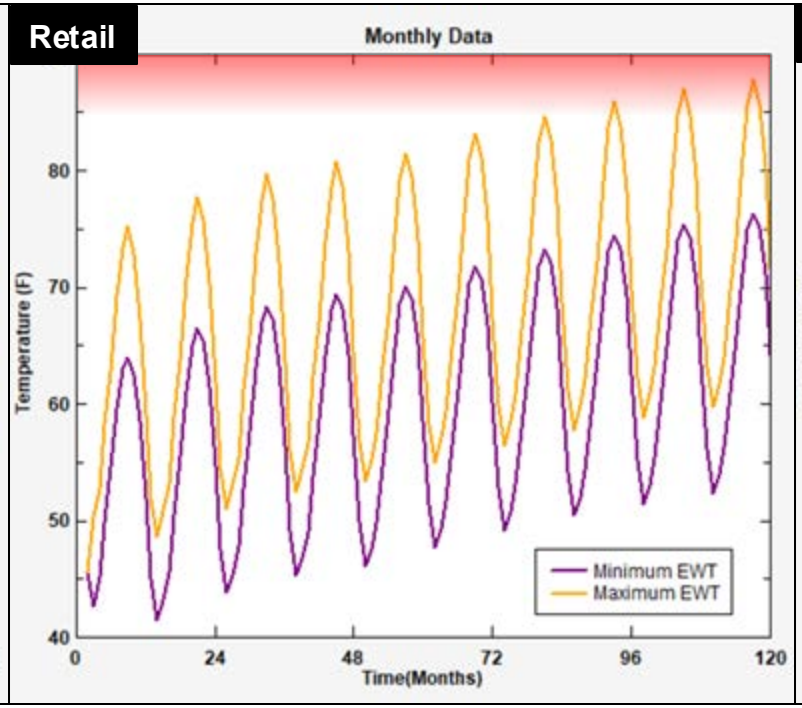
Peak Loads vs. Total Loads

- GHX more similar to a battery compared to a conventional system
- GHX temperature for church and retail store fall outside efficient operating parameters
- Can’t design off of peak loads and rules of thumb

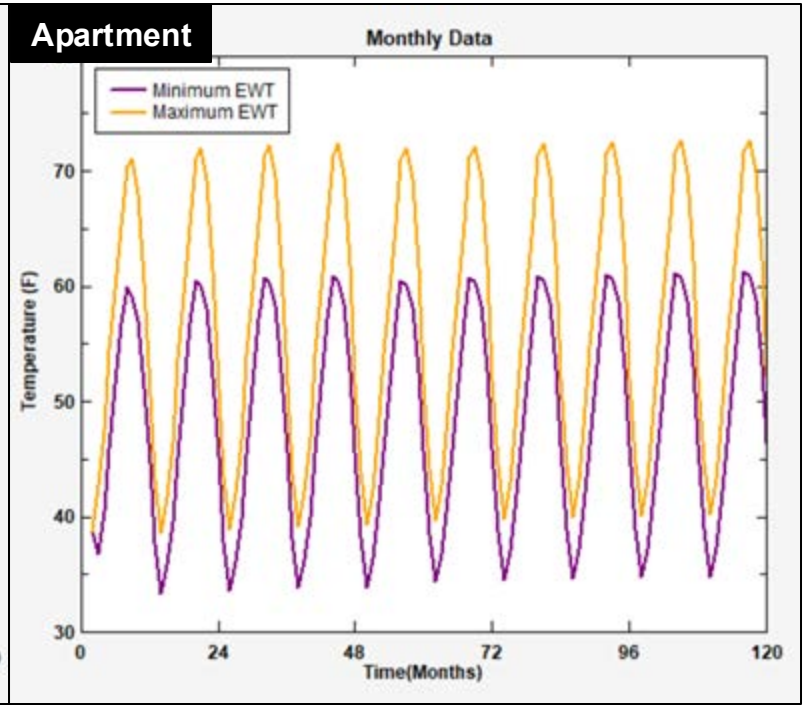
Church



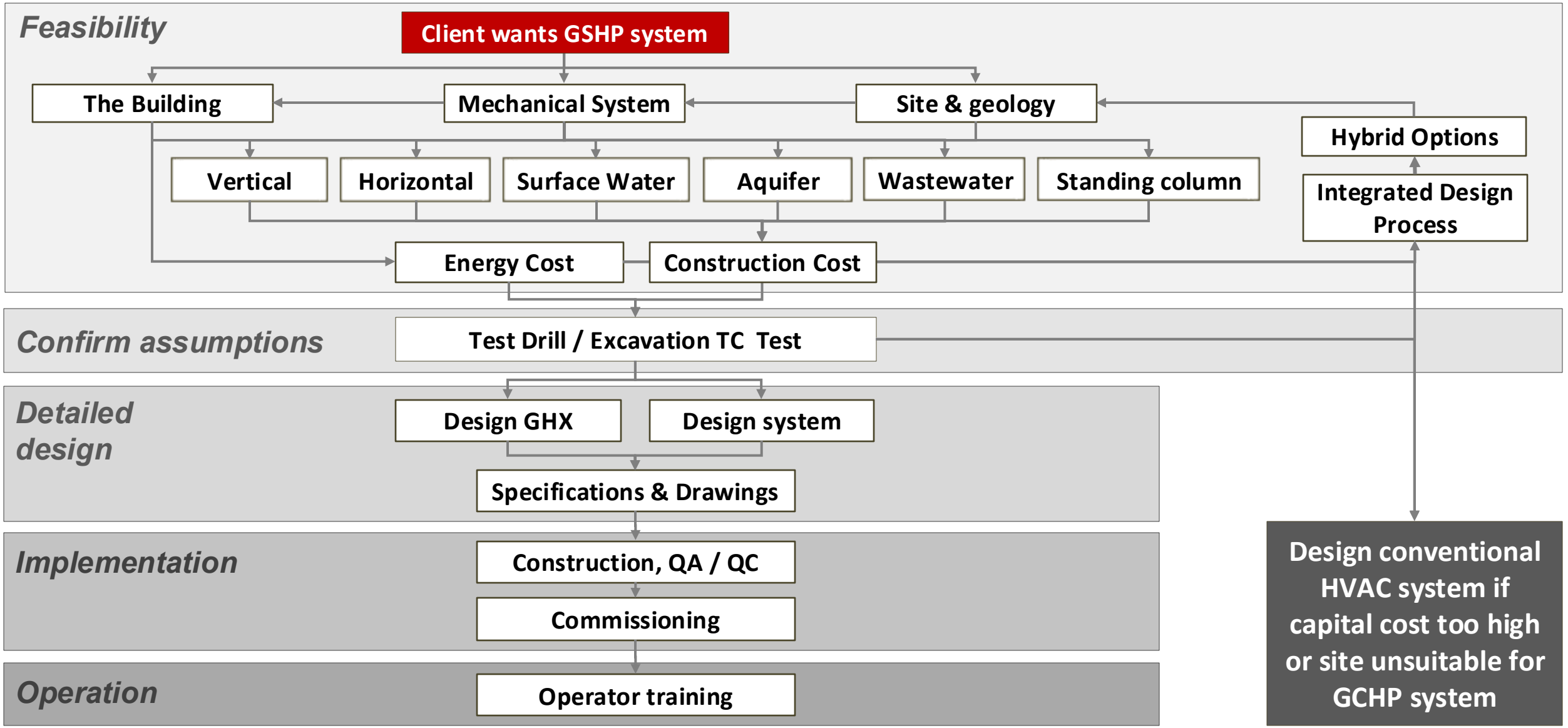
Retail



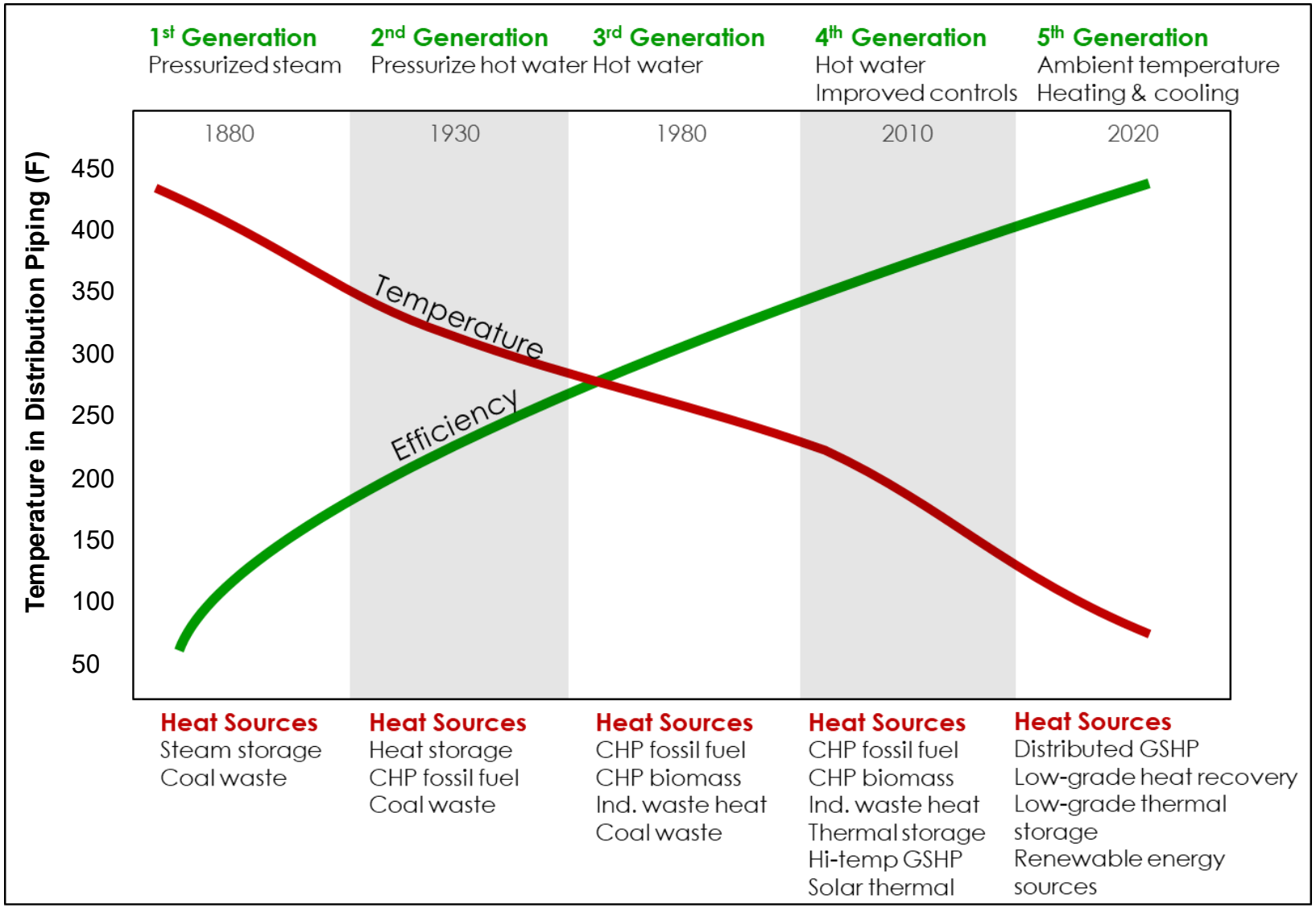
Apartment

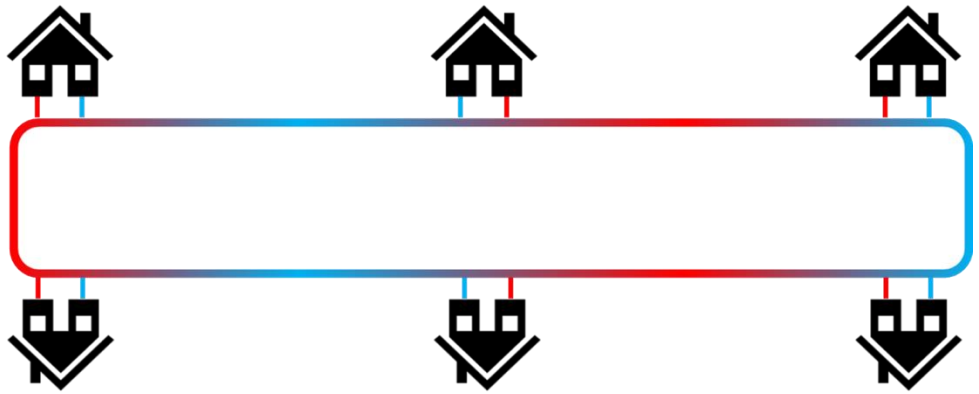


GSHP System Design Process



History of District Energy Systems





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