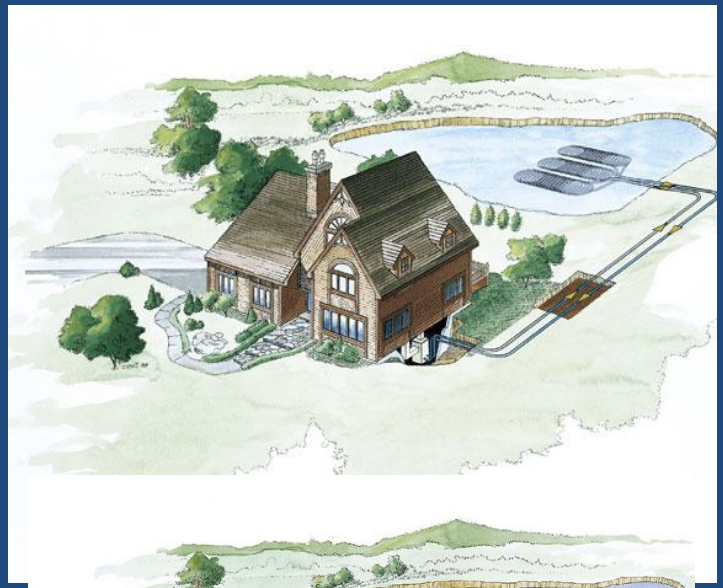
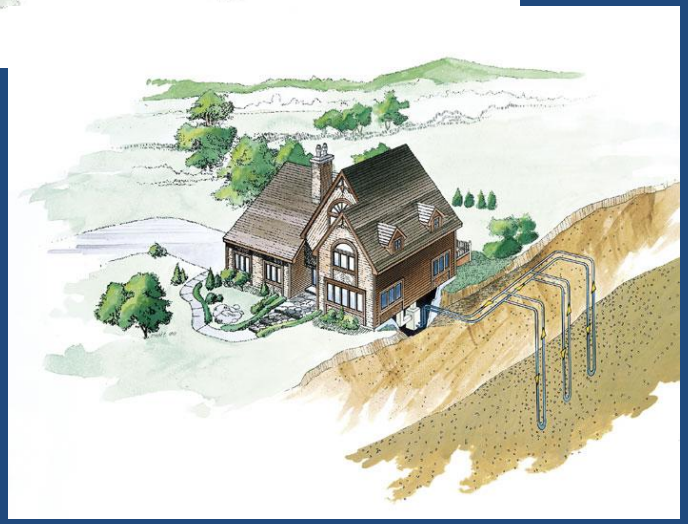
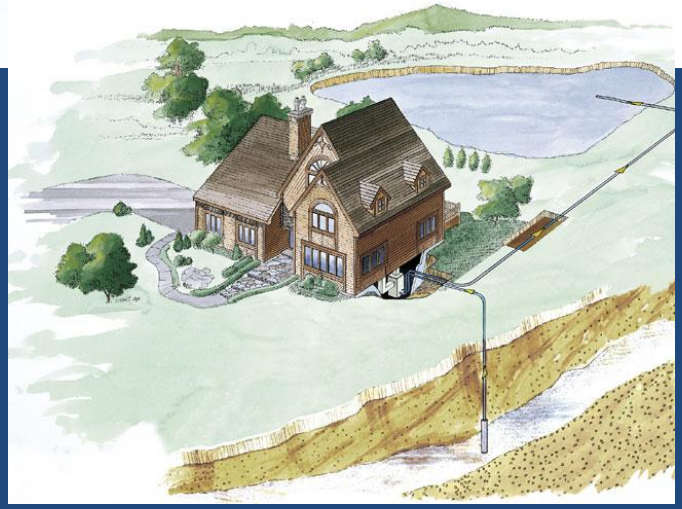
Residential Geothermal
Saving Energy







ClimateMaster Learning Center

Introduction To Geothermal

- Subjects to be covered
  - Energy issues , sources and use
  - Geothermal opportunities and advantages
  - Basics of heat pump operation
  - Types of ground loops
  - Basic ground loop installation issues

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Advantages of Geothermal

1. It reduces members energy costs

2. It creates a more comfortable environment

Electricity

Where does it all go?

“Built Environment”
HVAC

- Residential
- Commercial
- Institutional

= 70% of all electric energy consumed

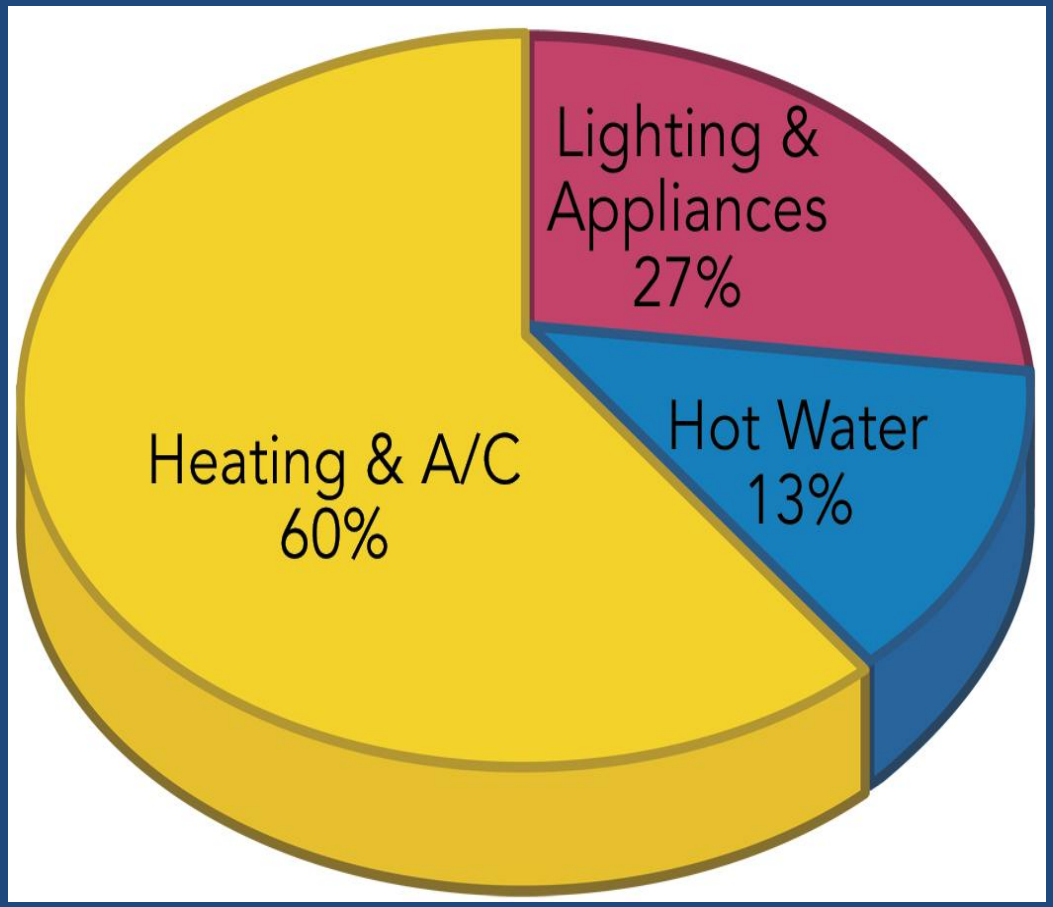
Oak Ridge National Labs

Residential Energy Usage

- *Heating and air conditioning*
- *Lighting*
- *Domestic hot water*

Residential Energy Consumption

Conventional Technologies



Over 70% of the energy consumed by a typical home is used to meet thermal loads

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Ordinary Furnace Efficiency

30% of Energy Lost (unusable energy)

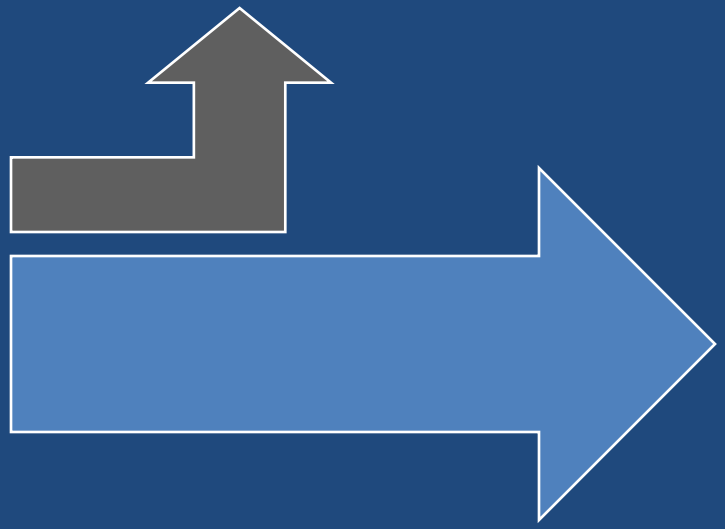
To Outdoors Through the Chimney

1 Unit

Of Fuel Used To

Generate Heat

(Purchased)



Only 70 - 95% of Energy Purchased Gets Into the Home

(usable energy)

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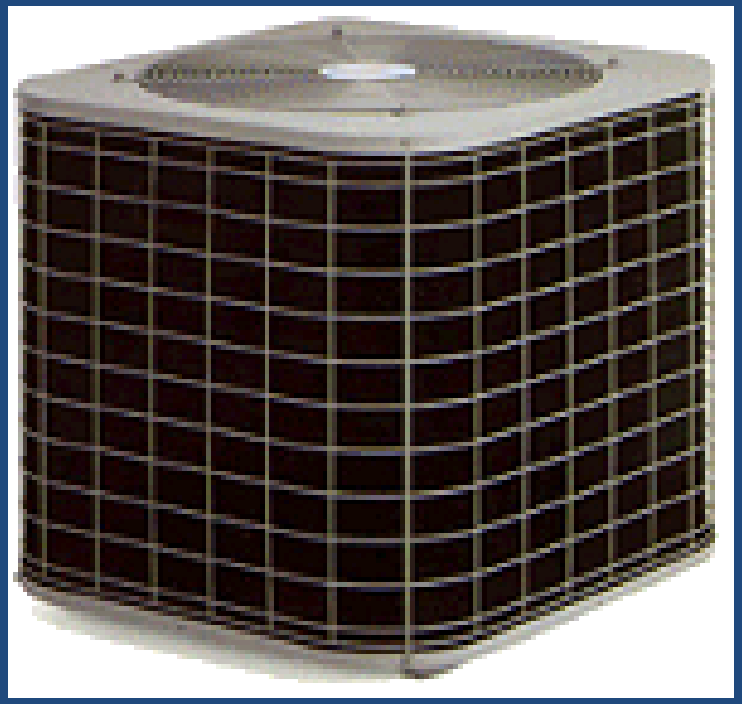
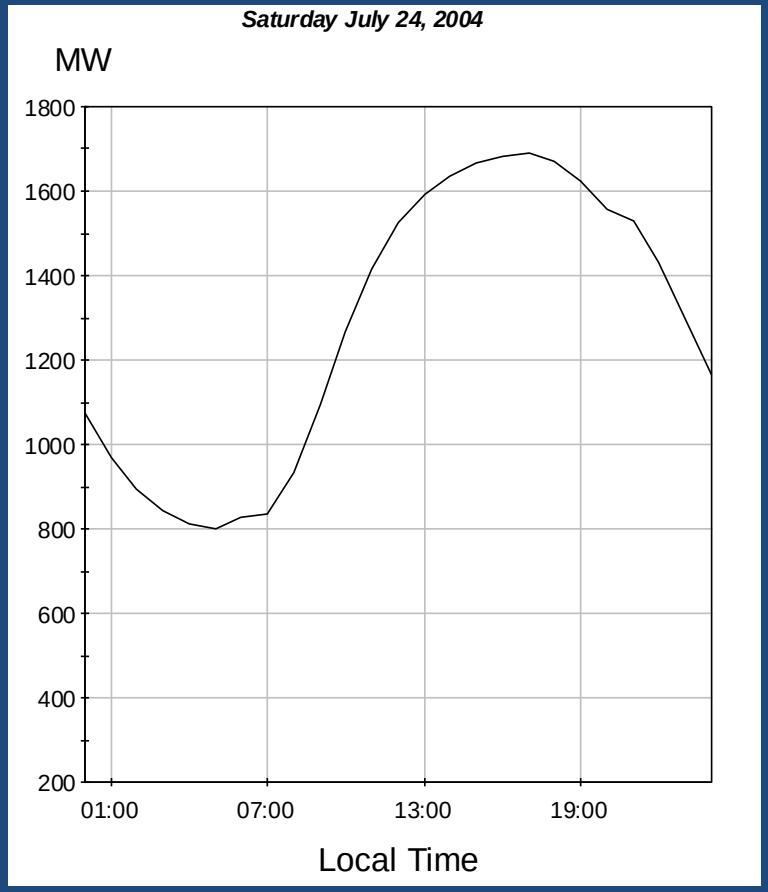
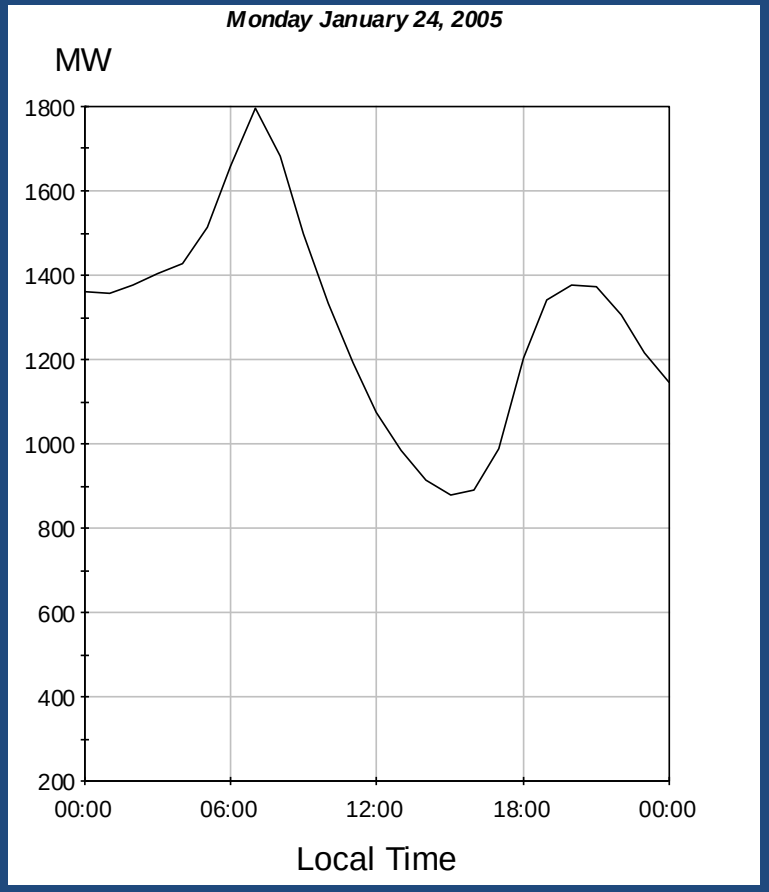
Air Source Heat Pumps
a mixed blessing



Identified Issue – Winter Peaking





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Geothermal Heat Pump
The Superior Solution

- *Renewable resource*
- *Highly energy efficient*
- *Available virtually everywhere*
- *Provides local employment*

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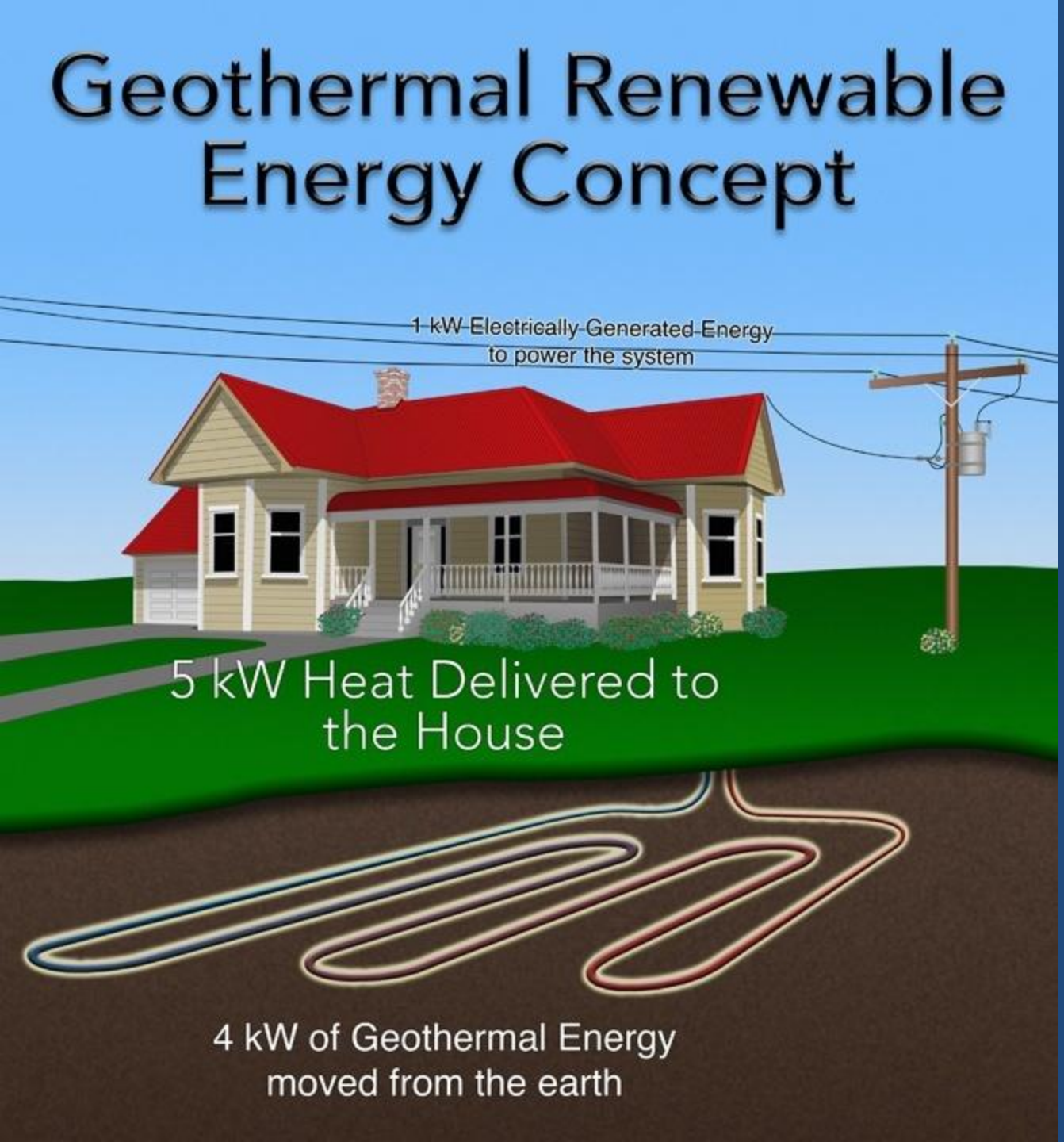
Geothermal Renewable Energy Concept



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Geothermal Heat Pump Efficiency

400-600% Efficient

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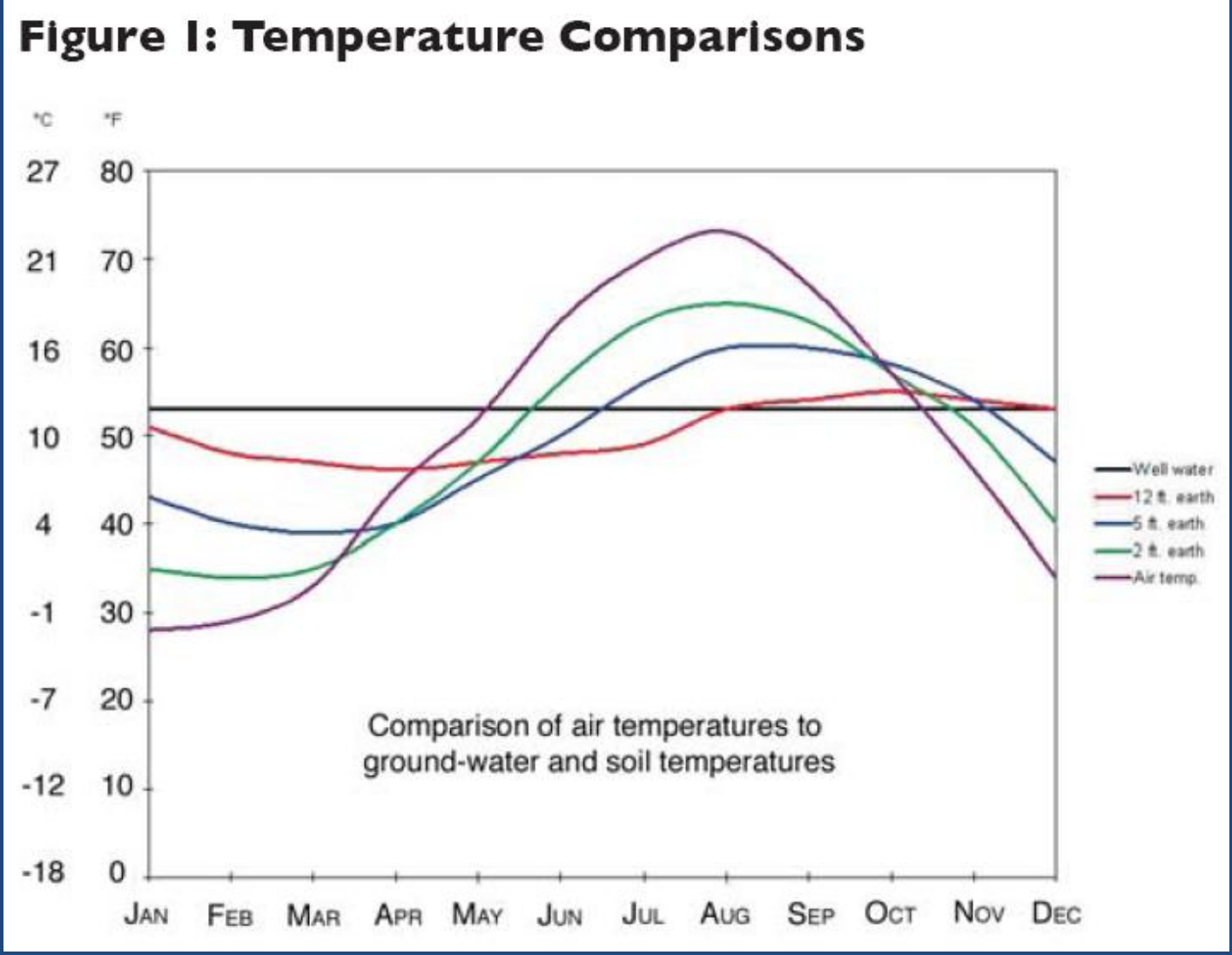
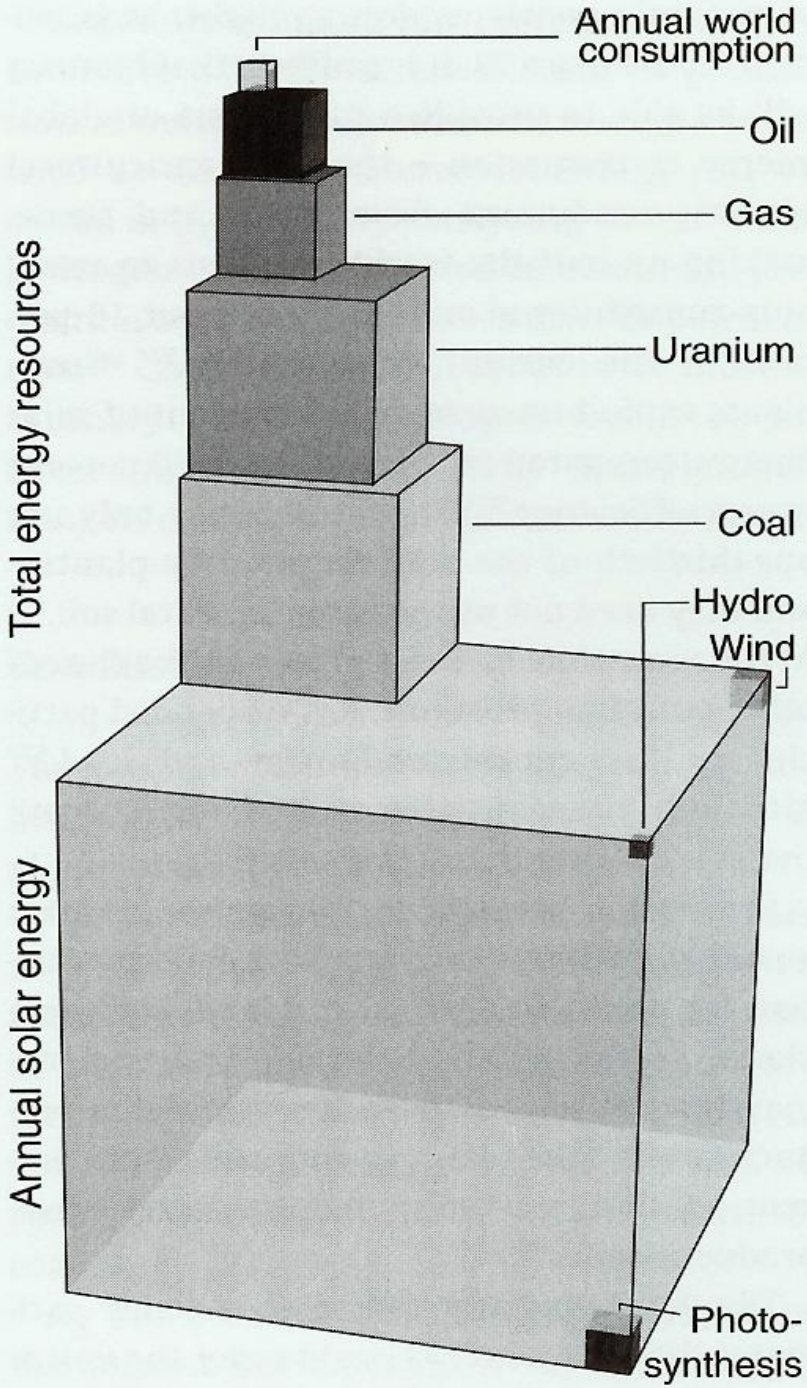
Ground Source HP

A Renewable Resource

47% of the solar energy falling on our planet is absorbed by the Earth's surface…

Earth is a better Energy Source





Our Most Abundant Resource

- Greater than
  - Wind
  - Photovoltaic
  - Solar Thermal
  - Coal
  - Nuclear
  - All fossil fuels combined

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Geothermal Heat Pumps are one of the Most Effective and Deployable…

… producing the lowest carbon dioxide emissions, including all source effects, of all available space-conditioning technologies

(EPA, 1993)

Geothermal Heat Pump Efficiency

1 unit of energy from the grid

Plus:
3-5 units of "free" energy from the earth

Yields:
4-6 units of energy for the building

400-600% Efficient

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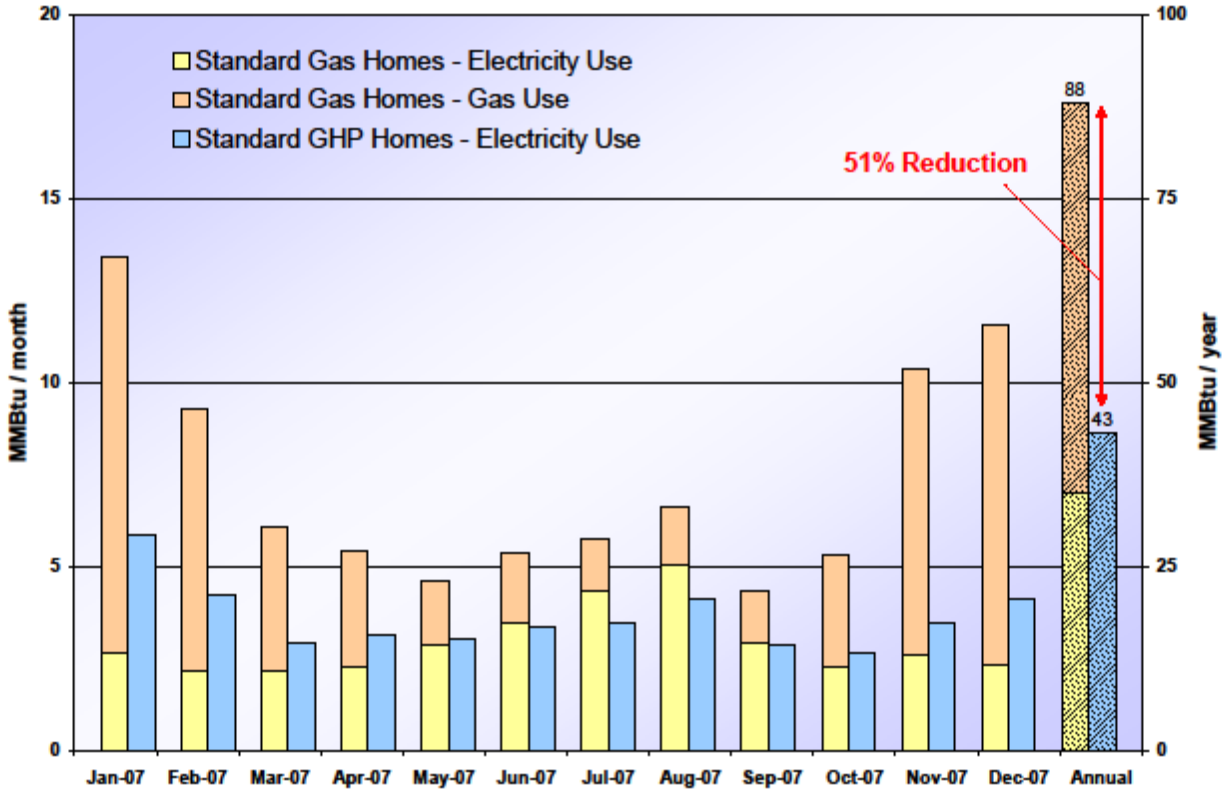
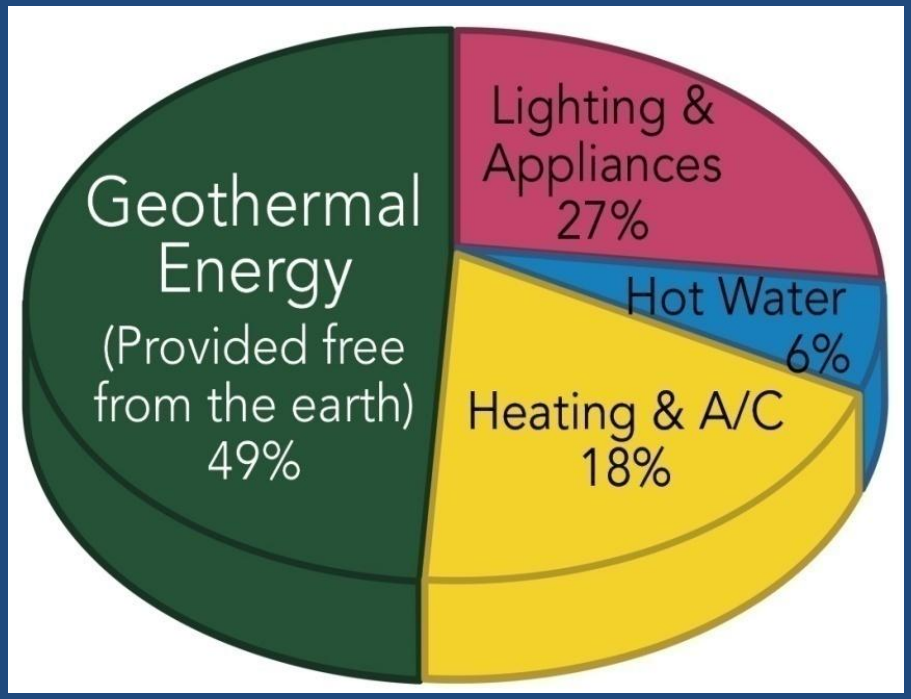
Average Metered Energy Consumption

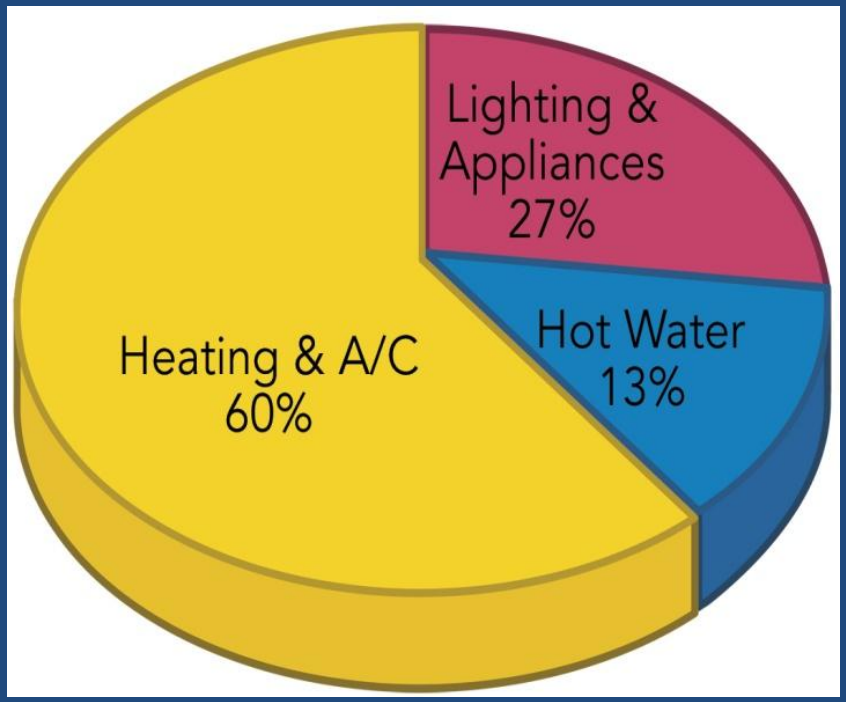


HVAC Energy Use Comparisons

Reduces energy consumption by 50%



Geothermal HVAC - Home



Conventional HVAC - Home

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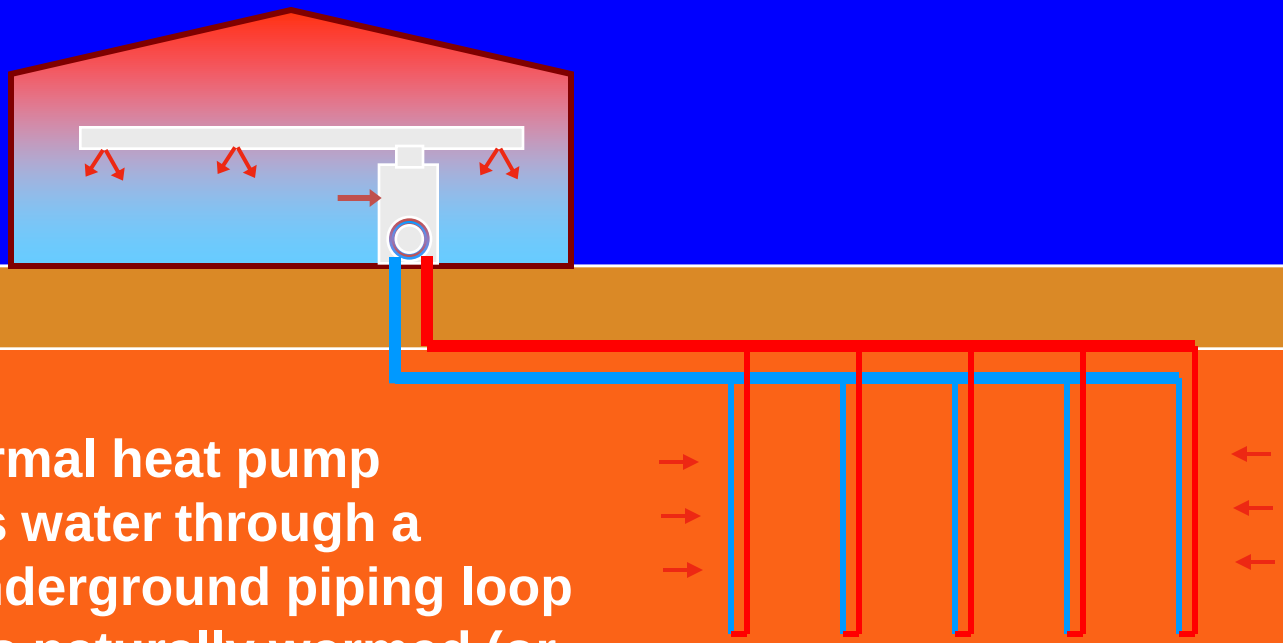
Basic Geothermal Operation

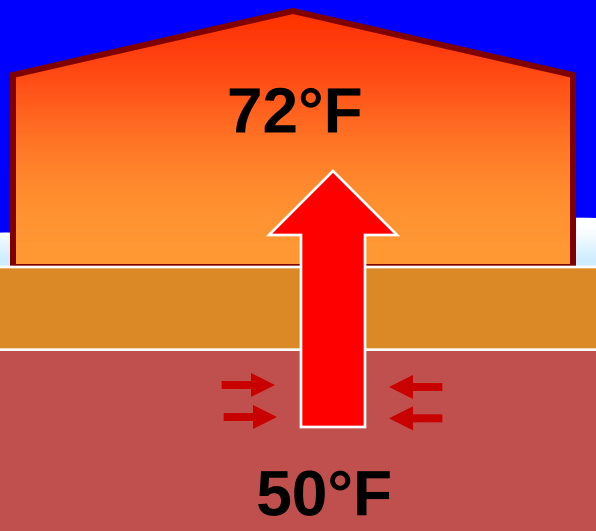
...using Heat Pump Technology



A geothermal heat pump circulates water through a sealed underground piping loop where it is naturally warmed (or cooled) by the earth

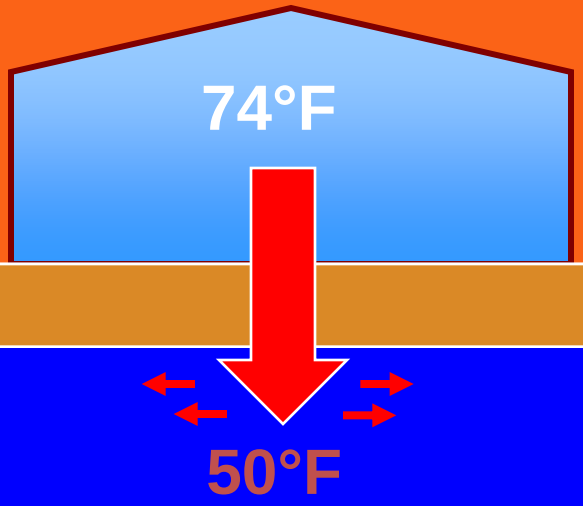
The Earth is the Source of Heat in Winter…

Outdoor air
design temperature:
-5°F



A geothermal heat pump transfers underground heat into the building to provide heating

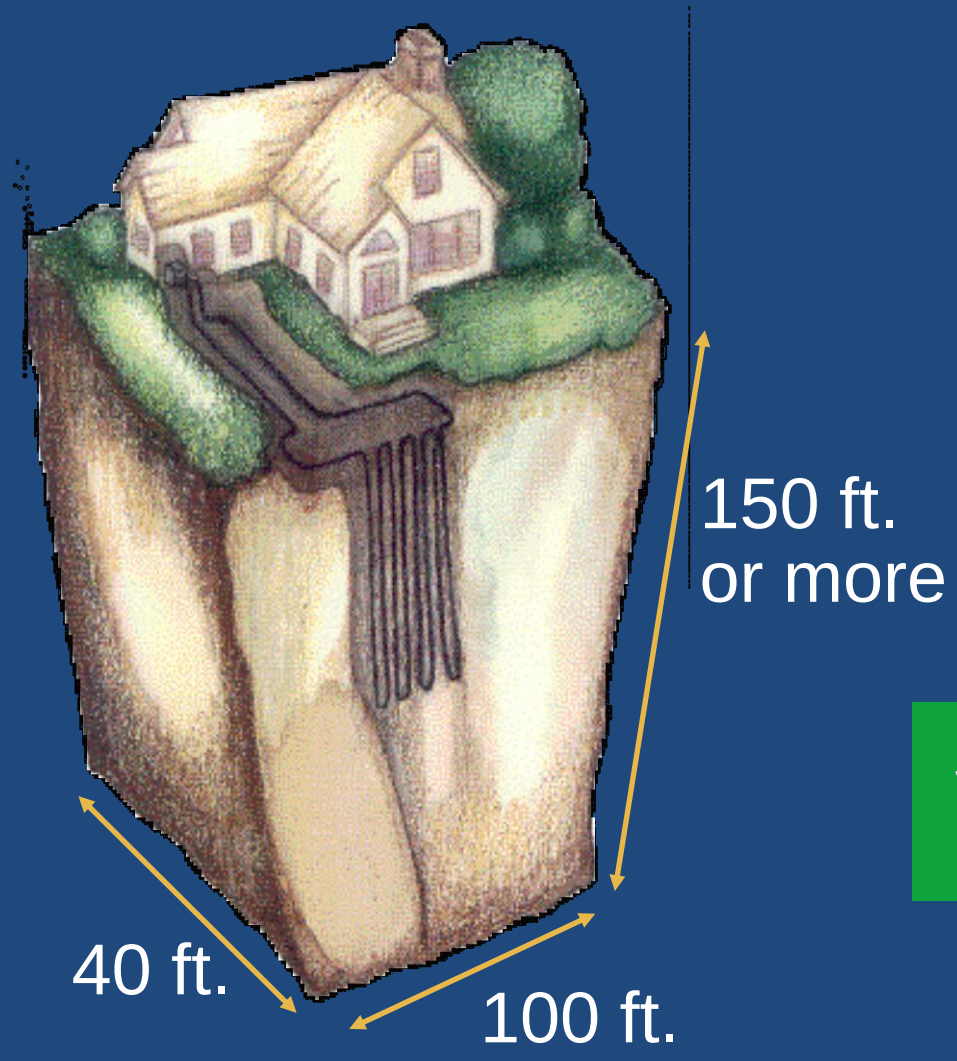
…and an Efficient Place to Reject or Store Heat in Summer…



Outdoor air design temperature: 95°F

A geothermal heat pump transfers heat from the building into the ground to provide cooling

The Unlimited Energy Source



Lots of

Energy Available

40 BTUs Per Cubic Foot

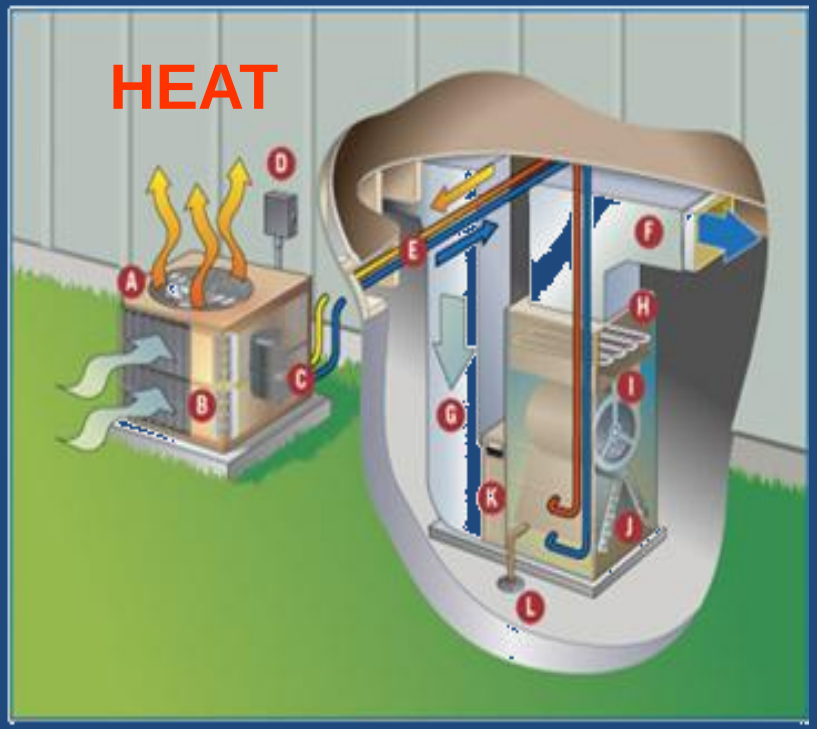
Small Yard Space =
Large Heat Source

Geothermal System Components

- *Heat pump*
- *Ground loop*

Heat Pumps Are All Around Us…

Air conditioners and air-source heat pumps transfer heat from inside houses to the air outside



Refrigerators transfer heat from food into the kitchen

Ground Source Heat Pump
Advantages

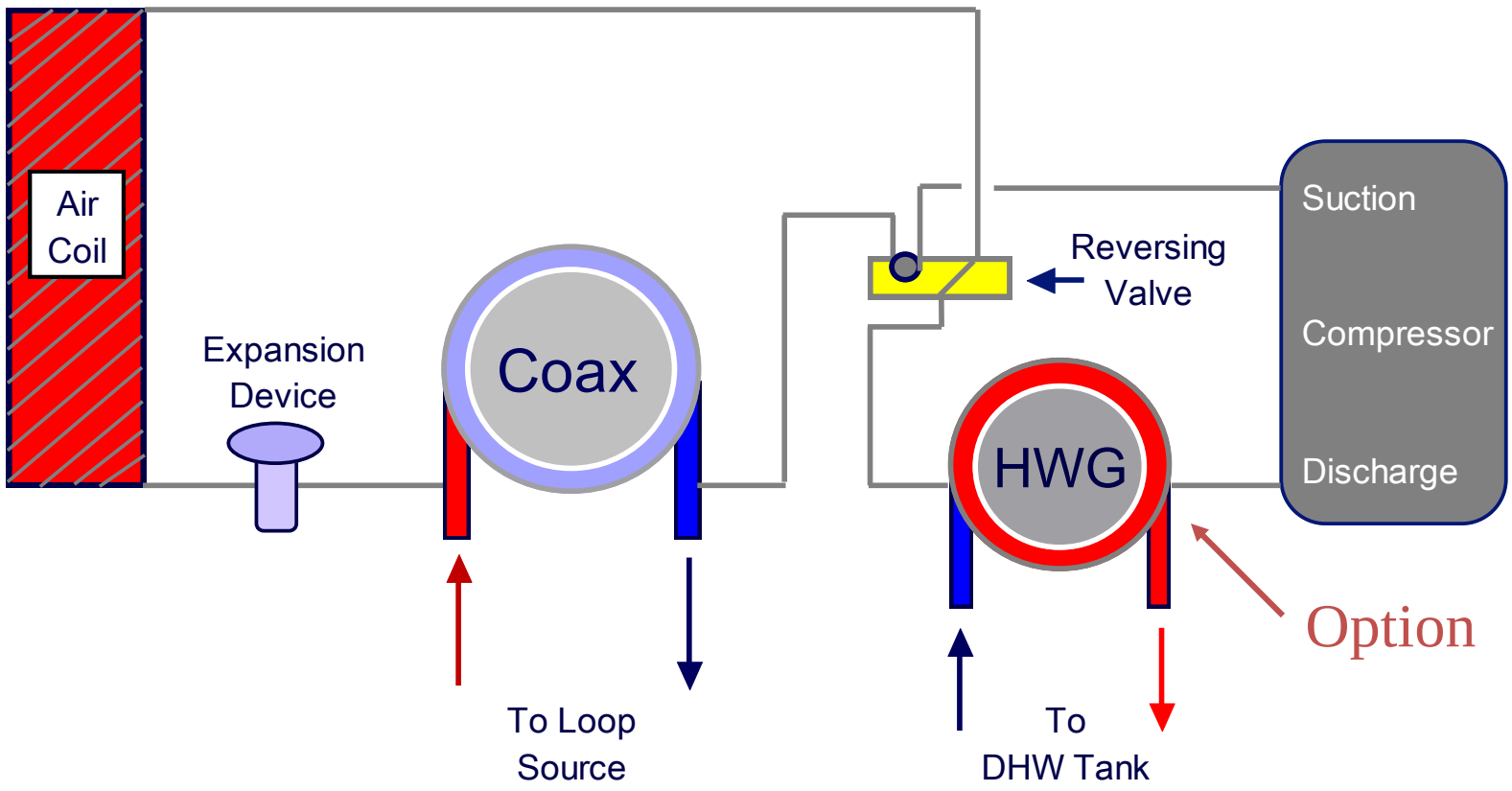
- *No defrost cycle – improved efficiency*
- *No outdoor enclosure required – less expensive (non-split)*
- *Ground moderates EWT – improved efficiency*
- *Quiet operation – no outdoor compressor*

Heat Pump Components

- *Compressor*
- *Refrigerant reversing valve*
- *Metering device – TXV*
- *Air heat exchanger – air coil*
- *Electrical Controls*
- *Fluid heat exchanger – ground loop (Coax)*

Heating Cycle

Refrigeration Circuit



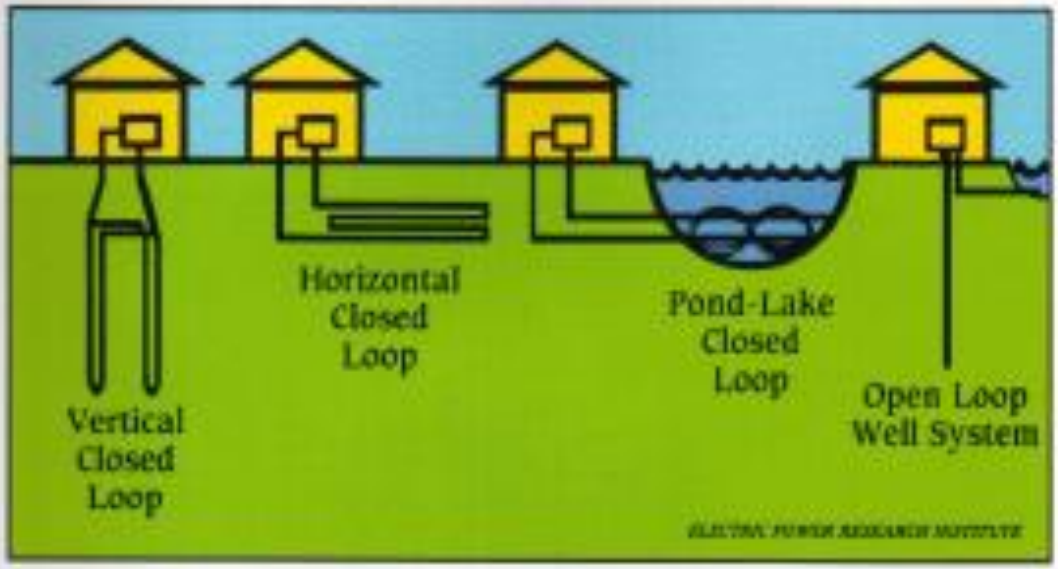
Ground Loop Design
The critical component

1. Requires specialized training
2. Installer needs to be certified
3. Installations should be inspected

Geothermal Loop Options

- **Closed loops** – Fluid is circulated within a buried, continuous loop
  - Two types
    - Vertical
    - Horizontal
- **Open Loops** – Water is pumped and dumped or re-injected
  - Two Types
    - Pond/Lake
    - Well systems

Typical Geothermal Earth Loop Designs



There are several ways to connect your home to the earth's energy battery. The best configuration is the one that can be installed at your location for the least cost.

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Geothermal Design Basics

- *The ground loop*

Equipment Sizing

- Once Building Loads are determined use our **GeoDesigner Software** to assist in the final design.

  Since the equipment capacity is directly related to the EWT (Entering Water Temperature), the type of heat source/heat sink must be considered when sizing the equipment.

Ground Source (GSHP) / Closed Loop

- Benefits
  - Lower system maintenance
  - No additional water requirements
- Hurdles
  - Requires more land space
  - First cost

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Closed Loop
Basic Design Rules

- Always prepare a site plan
- Special consideration should be given to minimum distances from items such as Lot Lines, Septic/Sewer, Water or other utilities
- Always check Local, County or State Regulations for Permits, Documentation, and Inspection Requirements

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Closed Loop
Basic Design Rules – cont.

- Fluids will take the path of least resistance,
- Equal fluid flow between the loops must be maintained!
  - Keep all loop lengths within 5% of each other
  - Use "reverse return" on the loop layout
  - Use "reverse return" at the manifold

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Closed Loop
Basic Design Rules – cont.

- Remove all rocks away from the pipe loop
- Use wide turns
- Avoid kinking the pipes during back fill – (reverse return)
- Always perform a Hydrostatic Pressure Test BEFORE burying the piping system

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Horizontal Loops
Basic Design Rules

- Backhoe or trench excavation.
  (In areas with any rock - typically backhoe only)
- Loop Piping installed below frost line
  - North - 4 - 6 ft max. depth
- 1 circuit and 3 gpm flow per ton
- Pipe per ton
  - North - 600 to 1000 ft
  - South - 700 to 1800 ft

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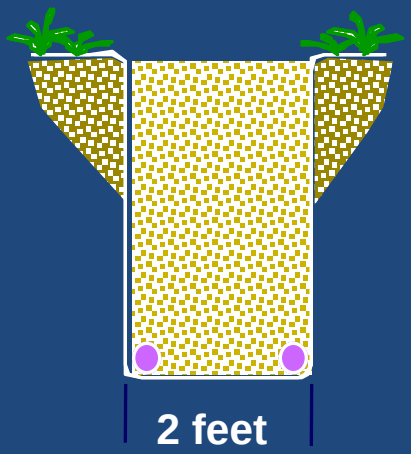
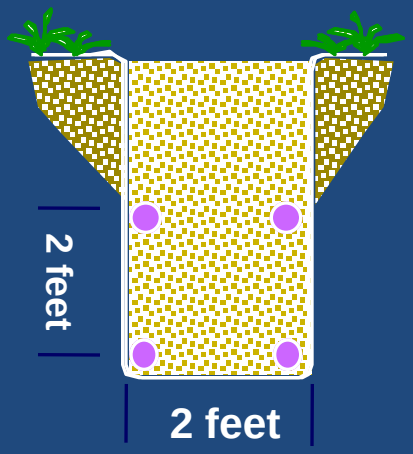
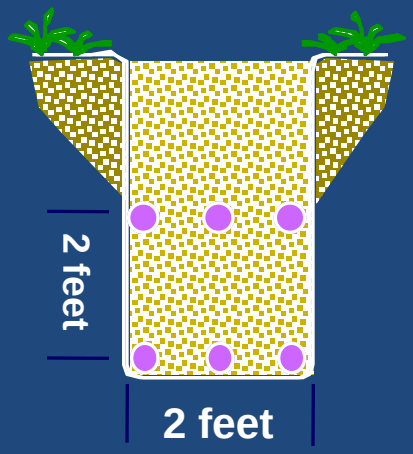
Horizontal Loop Types



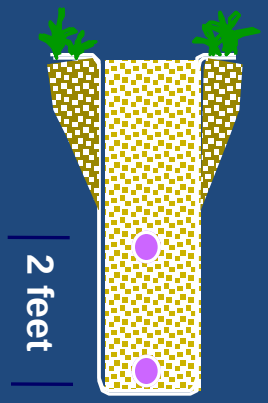
2 Pipe 1 circuit

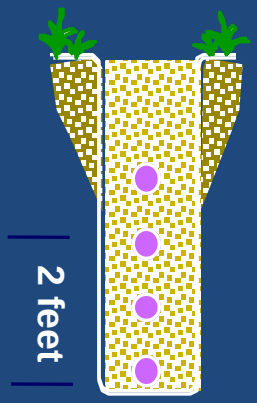


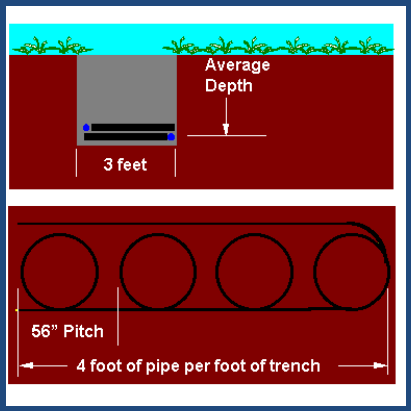
4 Pipe 2 circuits



6 Pipe 3 circuits







Horizontal Slinky

4ft pipe/1 ft of trench

1 circuit per trench

Flow Controller IOM Page Figure 14

Backhoe Horizontal Trenching Example

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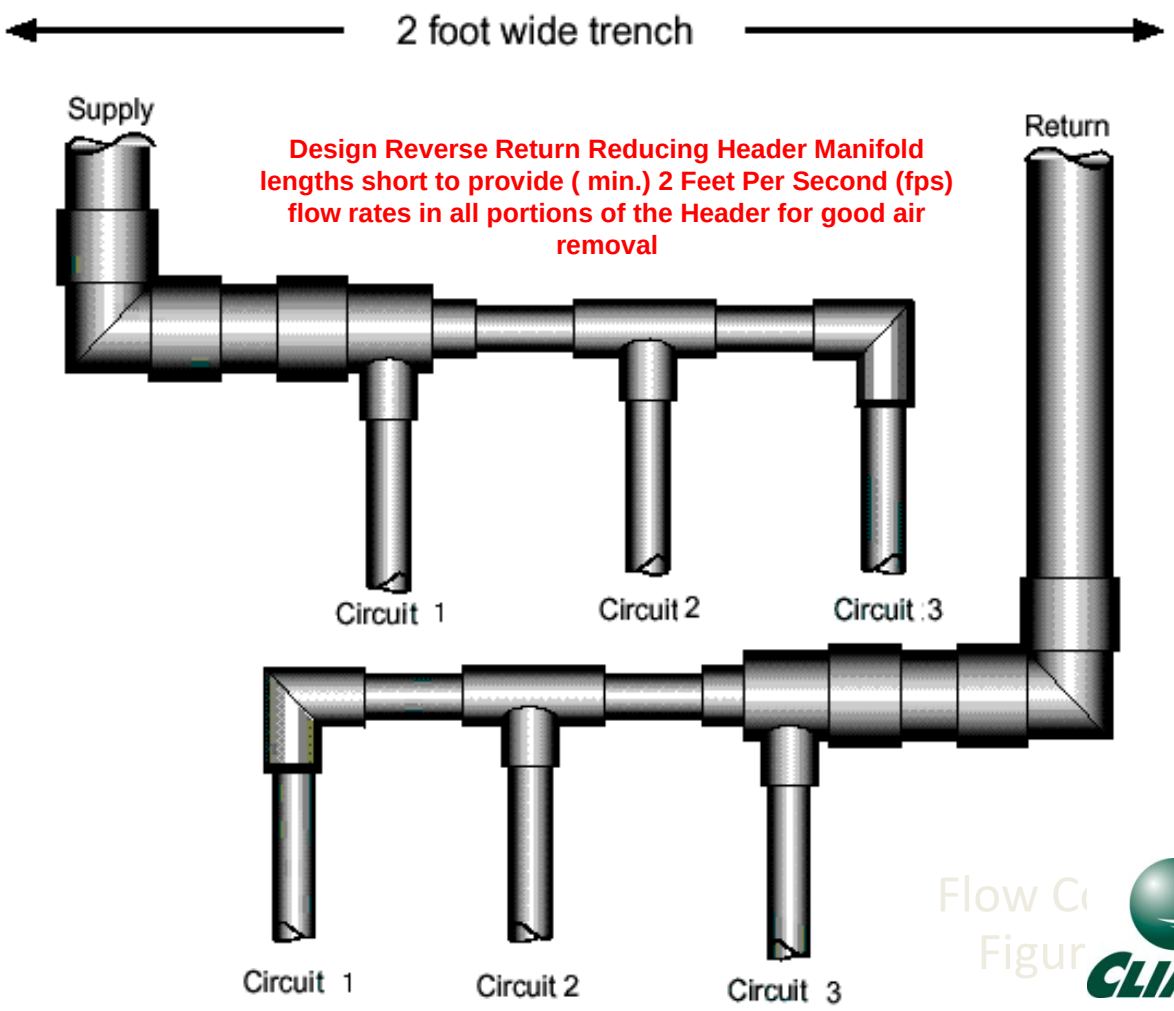
!Think Safety First!

Not a good trench to work in, keep the dirt away from trench to reduce danger of cave in

Horizontal Chain Trench - Example

Loop Circuit Header Manifold Reverse Return piping method



Flow C
Figur

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Vertical Loop installation

Vertical Loops
Basic Rules

- 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 -200ft/ton
  - South 250-300 ft/ton

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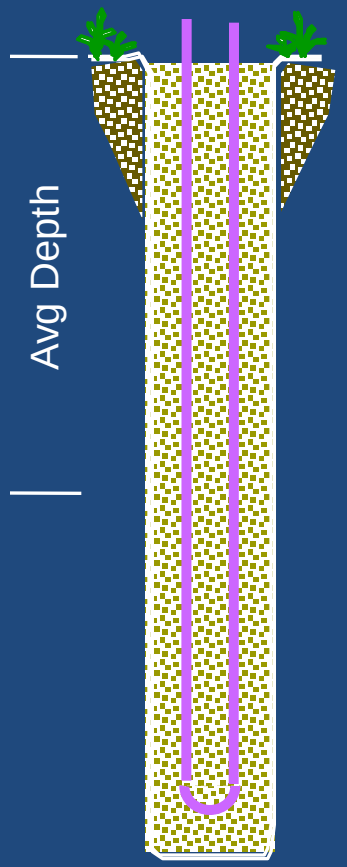
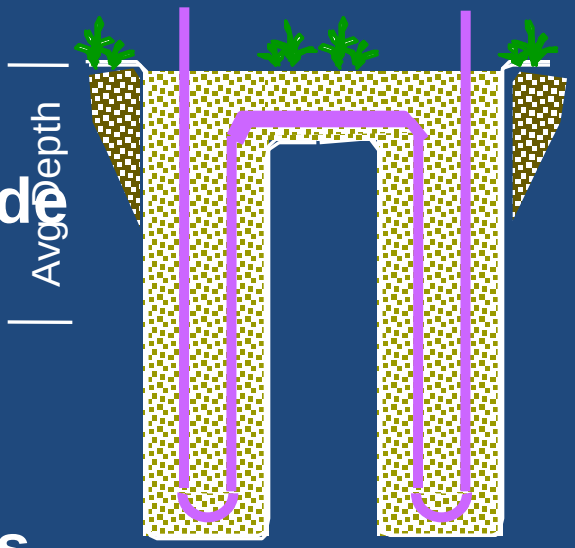
Vertical Loops



One Pair

Both layouts provide the same Total amount of pipe surface area …

Drilling conditions, cost and equipment may dictate what you can do.



When Loops are shallower than one ton per loop

Series/Parallel One Pair

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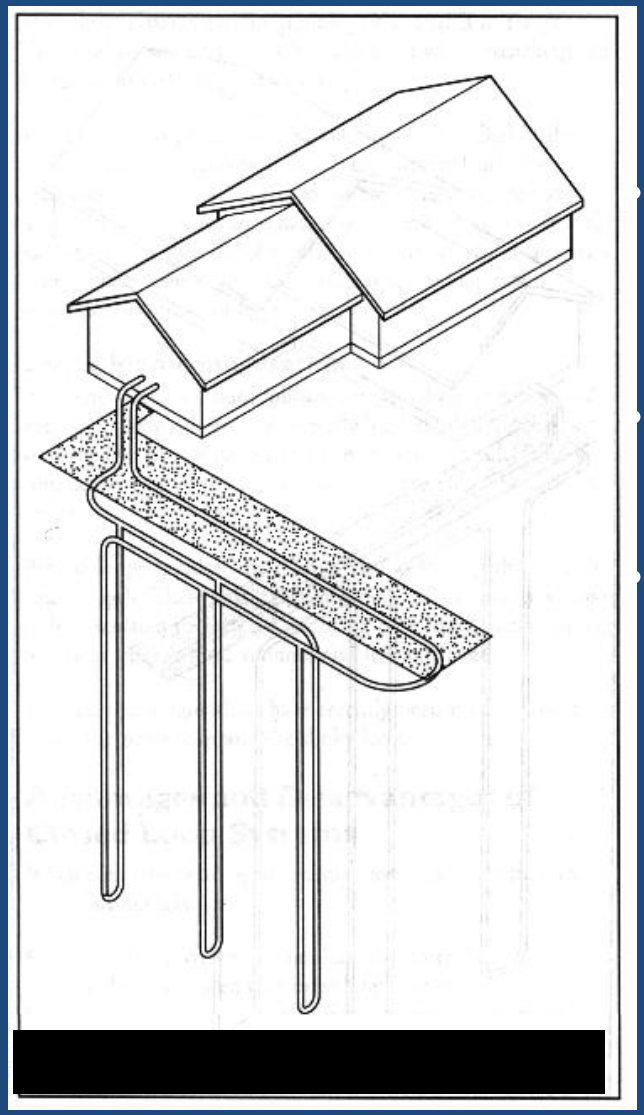
Vertical U-Bend with Grout

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

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Pond Loops

Basic Design Rules

- Least expensive ground loop
- Minimum 1/2 acre and 8 feet deep
- Pond should be within 300’ of structure
- In North - need ice cover for good operation
  - Utilizes 39 deg F water temp (no aeration).
  - Stagnate water body works best for heating
- Pipe Circuit length per ton
  - North and South 300-500 ft/ton

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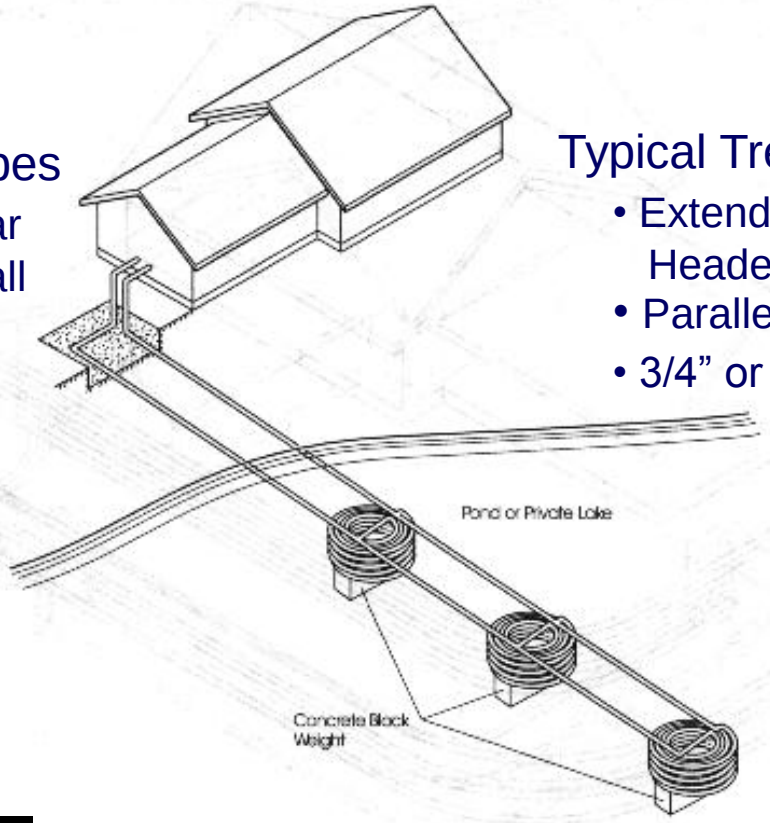
Pond/Lake Loop

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

[redacted]

Antifreeze Materials

- Methanol
  - least expensive and best performer, but toxic and flammable
- Propylene glycol
  - non-toxic and expensive, but lowest heat transfer and unusable in cold loop.

Note: Your local Law and Codes may dictate approved fluid type

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Methanol Safety

- *Always mix outdoors*
- *Keep away from any open flames*
- *Avoid ingestion – highly toxic*

Antifreeze containers –

(Blue containers best way to identify Methanol verse other fluids.)

Freeze Protection Chart

Antifreeze Percentages by Volume				
Type	Minimum Freeze Protection Temperatures			
Temperature	10 °F	15 °F	20 °F	25 °F
Methanol	25%	21%	16%	10%
Propylene Glycol	38%	25%	22%	15%

12/23/05Rev3vcb

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Recommended Freeze Protection

Flow Controller 3 - Installation, Application, and Maintenance

ANTIFREEZE SELECTION

Table 4: Antifreeze Percentages by Volume

Type	Minimum Temperature for Low Temperature Protection			
	10°F [-12.2°C]	15°F [-9.4°C]	20°F [-6.7°C]	25°F [-3.9°C]
Methanol	25%	21%	16%	10%
100% USP food grade Propylene Glycol	38%	25%	22%	15%
Ethanol*	29%	25%	20%	14%

* Must not be denatured with any petroleum based product

IOM: D Page 14

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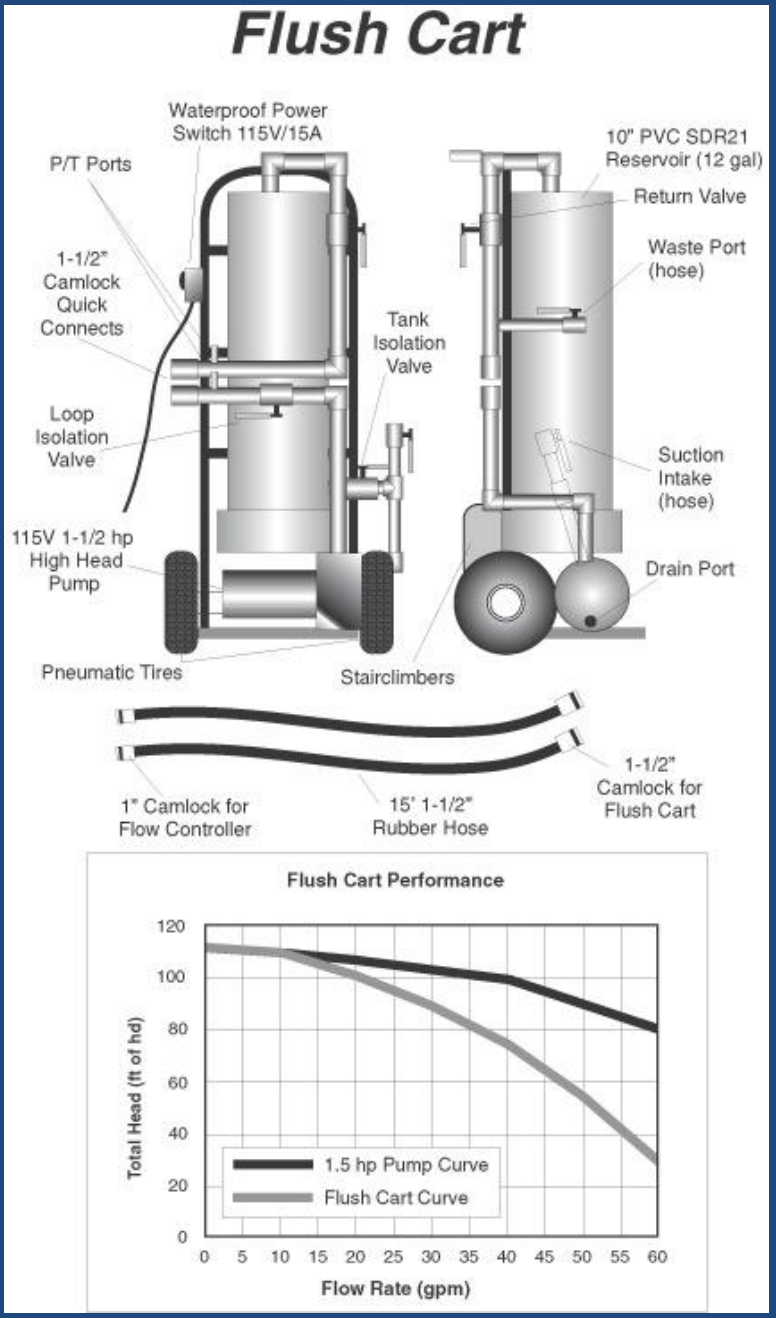
Ground Water Open Loop
Open Loop/Well Water

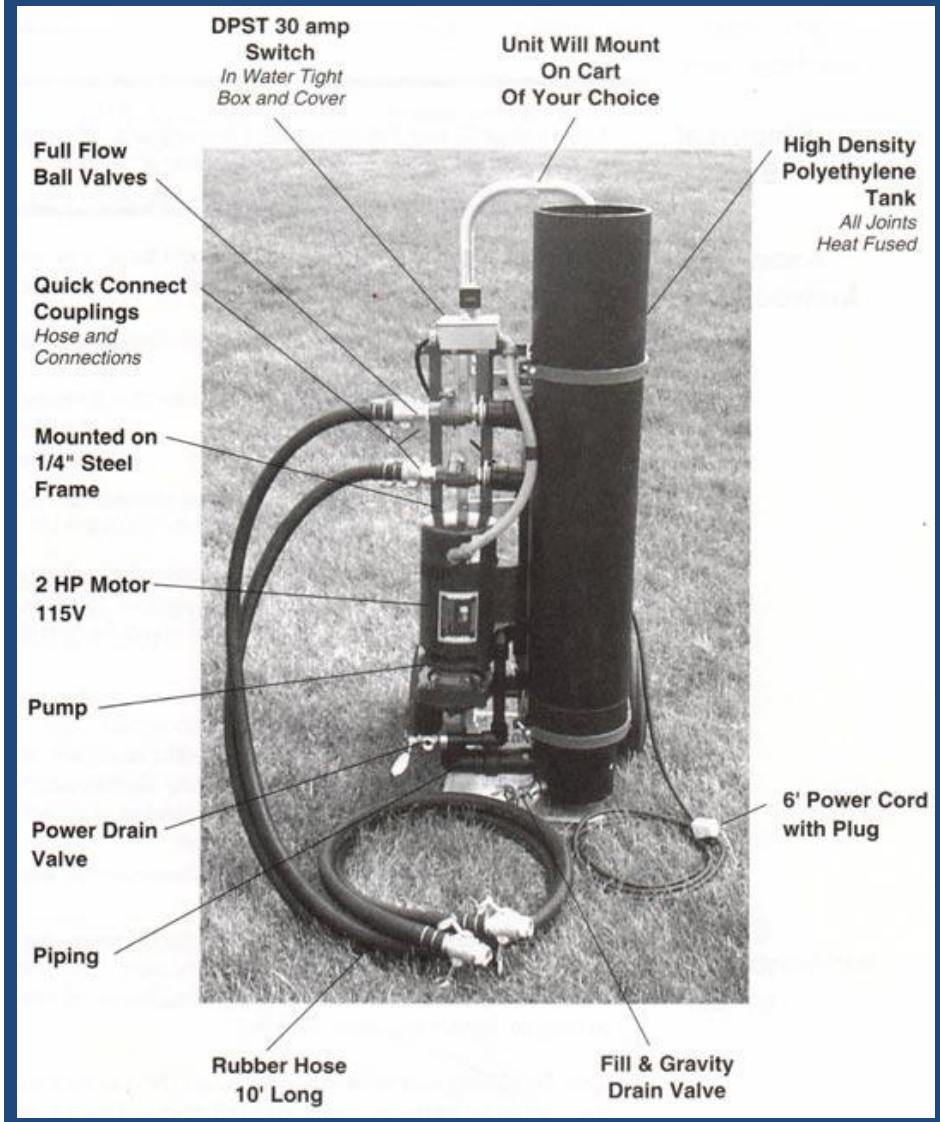
- Benefits
  - Lowest first cost
  - No land requirement
  - Fast installation for retrofits
- Hurdles
  - Requires clean water and maintenance
  - Larger well pump/pressure tank
  - Getting rid of water can be difficult
  - Water Hammer

Loop Flushing

- Critical step
  - Cleans any debris from the loop
  - Flushes air from the system
  - Mixes antifreeze solution in loop
  - Pressurizes loop

Flush Cart


Flush Cart
Waterproof Power Switch 115V/15A
P/T Ports
10" PVC SDR21 Reservoir (12 gal)
Return Valve
Waste Port (hose)
1-1/2" Camlock Quick Connects
Tank Isolation Valve
Loop Isolation Valve
Suction Intake (hose)
115V 1-1/2 hp High Head Pump
Drain Port
Pneumatic Tires
Stairclimbers
1" Camlock for Flow Controller
15' 1-1/2" Rubber Hose
1-1/2" Camlock for Flush Cart
Flush Cart Performance
Total Head (ft of hd)
120
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60
Flow Rate (gpm)
1.5 hp Pump Curve
Flush Cart Curve


DPST 30 amp Switch
In Water Tight Box and Cover
Unit Will Mount On Cart Of Your Choice
Full Flow Ball Valves
High Density Polyethylene Tank
All Joints Heat Fused
Quick Connect Couplings
Hose and Connections
Mounted on 1/4" Steel Frame
2 HP Motor 115V
Pump
6' Power Cord with Plug
Power Drain Valve
Piping
Rubber Hose 10' Long
Fill & Gravity Drain Valve

Flush Cart Example

(Jaquzzi pump – (GeoThermal Supply Co.)

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Equipment Sizing

- Building Heat Gain/Heat Loss is essential for any residential HVAC design, especially Geothermal Applications.
- Whole House methods are fine for the equipment sizing.
- Room by Room methods should always be used for Duct Sizing.

Comfort

1. Homes should be well sealed
2. More uniformly heat and cool than conventional HVAC systems
3. Systems are quieter

Equipment Applications

- Ducted Forced Air Systems
  - The most common type of heating and cooling distribution system is the ducted forced air system, which delivers warm or cool air to the living space. Water-to-air packaged units or split system heat pumps are typically connected to a central duct layout, which distributes the conditioned air to the various zones.
  - As in all forced air systems, properly designed and sealed ductwork is crucial to occupant comfort

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Questions?

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