Residential Geothermal
Saving Energy
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
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.
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)
Air Source Heat Pumps

*a mixed blessing*
Identified Issue – Winter Peaking

Saturday July 24, 2004

MW

Local Time

Monday January 24, 2005

MW

Local Time

CLIMATE MASTER
Geothermal Heat Pump
The Superior Solution

- Renewable resource
- Highly energy efficient
- Available virtually everywhere
- Provides local employment
Geothermal Renewable Energy Concept

1 kW Electrically Generated Energy to power the system

5 kW Heat Delivered to the House

4 kW of Geothermal Energy moved from the earth
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
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

Figure 1: Temperature Comparisons

Comparison of air temperatures to ground-water and soil temperatures
Our Most Abundant Resource

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

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Average Metered Energy Consumption

- Standard Gas Homes - Electricity Use
- Standard Gas Homes - Gas Use
- Standard GHP Homes - Electricity Use

51% Reduction

MMBtu / month

Jan-07 - Dec-07

Annual

50

25

20

15

10

5

0
HVAC Energy Use Comparisons

Reduces energy consumption by 50%

Geothermal HVAC - Home

Conventional HVAC - Home
Basic Geothermal Operation
A geothermal heat pump circulates water through a sealed underground piping loop where it is naturally warmed (or cooled) by the earth...using Heat Pump Technology.
The Earth is the Source of Heat in Winter...

Outdoor air design temperature: -5°F

72°F

50°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

Air Coil
Expansion Device
Coax
To Loop Source
HWG
To DHW Tank
Reversing Valve

Suction
Compressor
Discharge
Option

10/28/05vcbrev3
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
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.
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
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
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
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
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
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
!Think Safety First!
Not a good trench to work in, keep the dirt away from trench to reduce danger of cave in
Design Reverse Return Reducing Header Manifold lengths short to provide (min.) 2 Feet Per Second (fps) flow rates in all portions of the Header for good air removal.
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
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
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
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
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
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*
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Minimum Freeze Protection Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 °F</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>25%</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>38%</td>
</tr>
</tbody>
</table>

Flow Controller  IOM  Table 4  Page 8
**Recommended Freeze Protection**

Flow Controller: Installation, Application, and Maintenance

**ANTIFREEZE SELECTION**

Table 4: Antifreeze Percentages by Volume

<table>
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<tr>
<th>Type</th>
<th>Minimum Temperature for Low Temperature Protection</th>
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<tbody>
<tr>
<td></td>
<td>10°F [-12.2°C]</td>
</tr>
<tr>
<td>Methanol</td>
<td>25%</td>
</tr>
<tr>
<td>100% USP food grade Propylene Glycol</td>
<td>38%</td>
</tr>
<tr>
<td>Ethanol*</td>
<td>29%</td>
</tr>
</tbody>
</table>

* Must not be denatured with any petroleum based product
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 Performance

- 1.5 hp Pump Curve
- Flush Cart Curve

Flow Rate (gpm)

Total Head (ft of Hg)

0 20 40 60 80 100 120

10' Power Cord with Plug

Fill & Gravity Drain Valve

Rubber Hose 10' Long

Piping

Power Drain Valve

2 HP Motor 115V

Pump

Mounted on 1/4" Steel Frame

Quick Connect Couplings Hose and Connections

In Water Tight Box and Cover

Unit Will Mount On Cart Of Your Choice

High Density Polyethylene Tank All Joints Heat Fused

Full Flow Ball Valves
Flush Cart Example

(Jaquuzzi pump – (GeoThermal Supply Co.)
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.
Questions?