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Energy Efficiency and Renewable Energy

# Geothermal
# Heating and Cooling Systems

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## What is geothermal?

GEO= EARTH

THERMAL = HEAT

- Use of the earth as a heat exchanger
- Can refer to various techniques
- A proven technology – 50 yrs +

## Call it what you will…

- Geothermal heat pumps (GHP)
- Geoexchange
- Ground source heat pumps (GSHP)
- Ground coupled heat pumps

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## How Does It Work ?

- Heat pumps remove heat from or add heat to the building
- The heat removed or added must be rejected to <u>something</u>:
  - Directly to outside air (like your house system)
  - To water, which in turn rejects heat to atmosphere via a cooling tower
  - To water, then to the earth (geothermal heat pumps)

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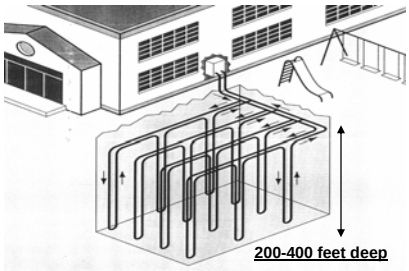
# Main Components of the Geothermal System: Outside

Earth Heat Exchanger (outside)

- The Earth Heat Exchanger (EHX) design is a fundamental issue.
- Integrated processes are critical for the efficiency and the reliability of an installation in the long term:
  - Design Engineering Assistance
  - Drilling, Looping, & Grouting
  - Trenching, Headering & Manifolding
  - Testing, Metering, Verification and Acceptance

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# Main Components of the Geothermal System: Inside

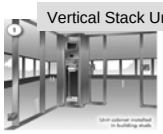
Geothermal Heat Pumps (inside)

- A decentralized design: each geothermal heat pump is installed in close proximity to the zone it serves.
- The geothermal heat pump is easy to service and does not require specialized training.

Horizontal Units

Console Units

Vertical Units


Vertical Stack Units

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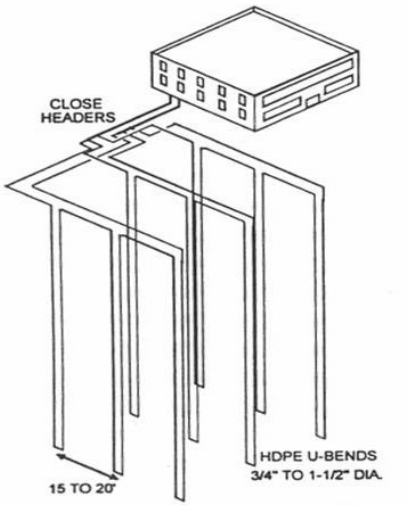
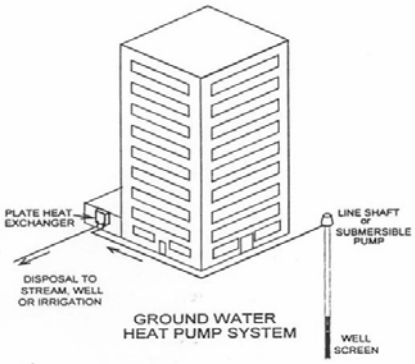



VERTICAL GROUND-COUPLED HEAT PUMP SYSTEM




GROUND WATER HEAT PUMP SYSTEM

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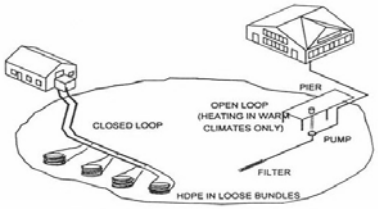
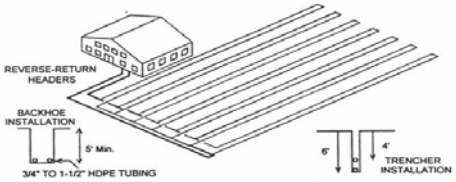
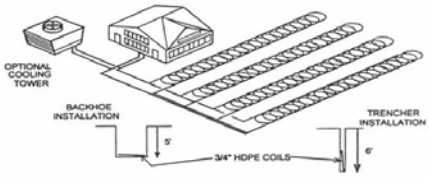


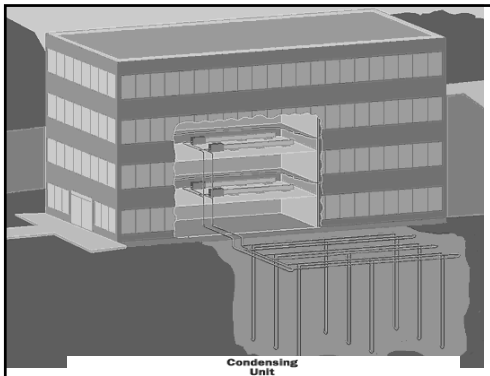

SURFACE WATER HEAT PUMP SYSTEM

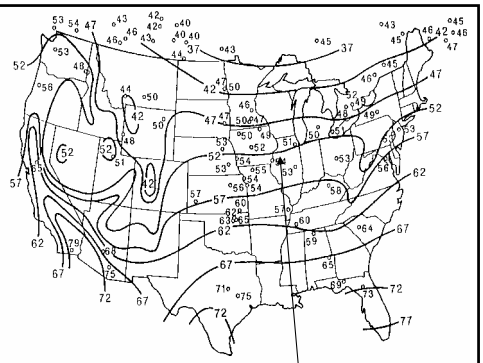



CONVENTIONAL HORIZONTAL GROUND-COUPLED HEAT PUMP SYSTEM

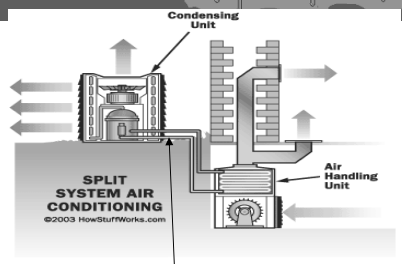



SLINKY COIL GROUND-COUPLED HEAT PUMP SYSTEM





AVERAGE GROUND TEMPERATURES




**WHICH IS EASIER TO REJECT HEAT TO ?**

**105 DEGREE AIR OR 54 DEGREE EARTH**

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# How Does It Affect Architectural Design ?

- Inside the building:
  - Plenum space: little or no difference compared to tower loop heat pumps, chilled water fan coils or vav box type systems
  - Mechanical rooms and shafts: less space than central air handlers
- Outside:
  - Roof: no units on the roof ( but can be)
  - No condensing units on the ground
  - No visible loop piping
  - Little affect on finished landscaping. Grading/ paving

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# Main Benefits of a GHP System (1)

## Compared to traditional Systems

- Utility Reduction (40% to 60% of the energy consumption of a building is for heating, cooling & hot water)*
  - No water consumption from Cooling Tower
  - No gas consumption for heating
  - GHP dramatically reduces electricity demand (kW) and electricity consumption (KWh) because the system uses the renewable energy stored in the earth.
- Operation and Maintenance Costs Reductions
  - GHP system can reduce up to 50% of the Operation & Maintenance costs (vs. chiller & boiler system)*.
- Return on Investment / Payback
  - Depending on the financial structure (equity vs. loan) of the investment, the average IRR is between 15% and 50%,
  - The average payback (simple) can be as low as 5 to 7 years.

**according to ASHRAE published reports*

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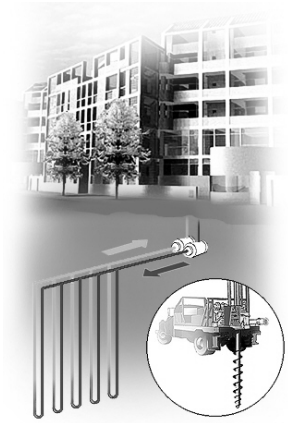
# Main Benefits of a GHP System (2)

## Compared to traditional Systems

- Eliminate gas boiler
  - No Mechanical Room: Free up additional space
  - Eliminate gas usage, enhance building safety
- Eliminate cooling tower
  - Elimination of unsightly equipment (cooling tower on top of the building roof) and, as a result, reduction in the risk of air-borne diseases
  - Eliminate chemical treatment of water
  - Eliminate water usage
- More comfortable interior environment
  - Individual thermostat control to customize comfort



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# Case Study

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## University Project

University HVAC Retrofit

- First 4 buildings (peak cooling 350 tons) of a 20-building retrofit planned over the next 4 years
- 1st Phase contract price - $2.9 million
  - Geothermal 4 buildings
  - Lighting retrofit 20 buildings
- 1st Phase paid through total energy savings
  - Financing capital cost
  - Immediate positive cash flow from project
  - $5.4 million in savings over 20 years
- Construction schedule May 12th – Sept 10th

***HVAC system before retrofit***

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## Drilling, Looping & Grouting

Drilling the wells for the Earth Heat Exchanger → Looping & Grouting with EnLink patented Coil Tubing Unit (CTU)

***The Drill Rig drills as deep as 400 feet***

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## Geothermal Drilling Needs

- Equipment built for the specific purpose of geothermal well installation
- Equipment suited for a variety of geologies that can be encountered on a project
- Each drilling machine capable of performing in all four drilling modes (Air rotary, Air hammer, Mud rotary and Sonic)
- Experienced equipment operators
- Professional management on site and at the corporate level

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# Drilling Techniques and Approaches

- The EnLink System has the capability to perform 4 major types of drilling (at same site, in same hole):
  - Sonic Displacement Drilling
    - Glacial till applications and other "unstable" formations are ideal for sonic displacement
  - Meet the standard for traditional modes on the same rig
    - Mud ( Wet Rotary)
    - Air Rotary
    - Down hole Hammer
  - Use partner firms to work in conjunction with EnLink rigs
    - Short time frame for completion.
    - EnLink cases unstable overburden; partner firm uses air hammer or rotary to complete. EnLink "stays ahead" of one or more air-only rigs.
    - EnLink loops and grouts and retrieves casing.

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# The EnLink system has the flexibility to drill in all geologies

Criteria for technique:
- Fastest rate of penetration to depth
- Two techniques are often used on the same hole to get to depth
- Techniques can vary across a single site due to geologic changes
- Stabilize the hole to receive the loop and grout
- Minimize negative effect on site from the DLG operation

| Geology<br>❖EnLink projects | Technique | Rationale & Benefits | Required Tools |
|---|---|---|---|
| Soft soils, gravel, cobbles, sands<br>❑New Ark<br>❑Canutillo<br>❑1st 100 feet Warrenton | Sonic (displacement drilling) | Speed, hole stabilization retrieval of casing | Sonic head, casing, displacement bit, tooling |
| Dry stable soils, dry clay, soft "rock"<br>❑Bridges CC | Air rotary | Site stays dry, can produce better ROP than MR if condition are dry | Air compressor, air bits specific to geology, cyclone to manage cuttings, tooling |
| Rock<br>❑2nd 250 feet Warrenton | Air Hammer | Maximum ROP in hard geologies | Compressor, hammer, rock bits, hammer lubrication system, ability to mix air and water for lubrication, drilling foam system, tooling, cyclone to manage cuttings |
| Wet clay, soft rock, 100% sand.<br>❑Kinnard School (CO)<br>❑New Madrid | Mud Rotary | Can be faster than sonic in certain geologies, Mud is used to stabilize the hole | Mud processor, bits, tooling |

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# Trenching & Manifolding

Trenching and Manifolding

***Well fields***

***Connecting the wells with each other***

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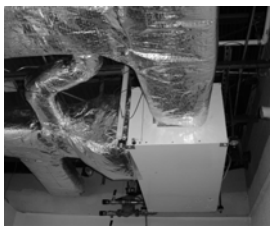
# Connection with building

Main connection to the building

Interior piping network connects all the Water Source Heat Pumps to the EHX



# Emission Reductions Over System Life

***LET'S DO SOMETHING FOR OUR PLANET***

**University emission reductions over system life,**

| Carbon Dioxide ($CO_2$) in pounds | Sulfur Dioxide ($SO_2$) in grams | Nitrogen Oxide ($NO_X$) in grams |
|---|---|---|
| 971,998 | 617,039 | 861,661 |

**. . . according to the EPA, are equivalent to planting 1,944,000 trees, or removing 3,888 vehicles from our roads.**

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# Design Requirements

- Monthly heating/cooling loads
- Geology – ground heat transfer rate (Thermal conductivity) and undisturbed ground temperature
- Land area available
- Number of building piping penetrations needed (modular loopfields)
- Flexibility from the drilling contractor on bore hole depths

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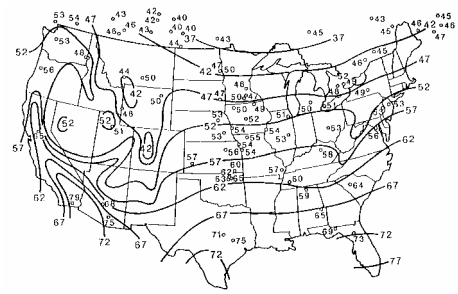
Geothermal & Geological Study

Thermal Conductivity Test



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Analysis of the building thermal needs & design of the EHX

***Analysis of the building heating and cooling load through Trane Analyzer***

***Design of the Earth Heat Exchanger (EHX) with EnLink Software (Geodevelopper)***

## Budgeting

- Interior heat pumps
- Interior piping (copper or HDPE)
- Pumping – central or distributive
- Controls
- Wellfield
  - # holes, depth, distance apart, loop piping size, backfill type

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## Learn more…

- Provide owner presentations on the technology
- Provide a feasibility study on the building
  - Include an economic and environmental impact
  - Evaluate comfort and health issues that can be addressed with geothermal
- Develop financing packages
- Partner with local mechanical contractors for a total solution

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*Thank You!*

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