



Army Corp. of Engineers

Geothermal Systems and Hybrid Design

**Louisville, Kentucky
August 17, 2011**

Thermotechnology



Robert Koschka
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Cas Air Co.
Local representative

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Topics:

Benefits of a WSHP System
Geothermal Loop Options
Economics
Hybrid Design – Cost savings
WSHP Products



Benefits Of Using A WSHP System



WSHP “Decentralized” System



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System Benefits

WSHP “Decentralized” Benefits

- **Simple Two Pipe Water Circuit**
- **Units Only Operate As Required By Individual Thermostats – DDC controls**
- **“Rejected Heat From Cooling Can Be Reused Elsewhere In The Building”.**
- **One Unit Failure Doesn’t Effect Other Units.**
- **Architectural Design Flexibility.**

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System Benefits - Summer Cooling Mode

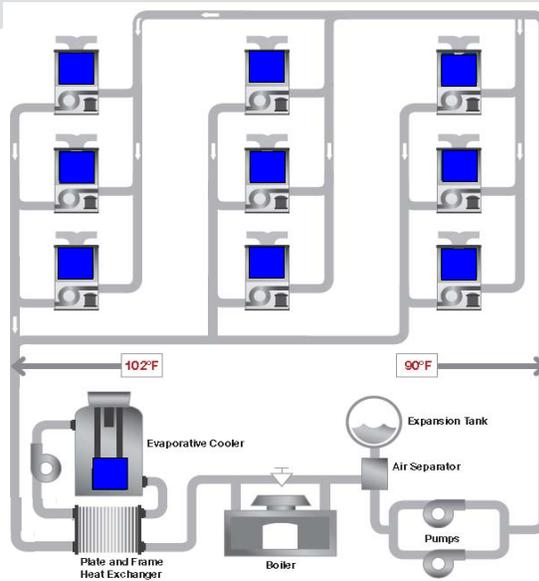


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DECENTRALIZED ADVANTAGES

Summer Cooling Mode



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System Benefits - Winter Heating Mode

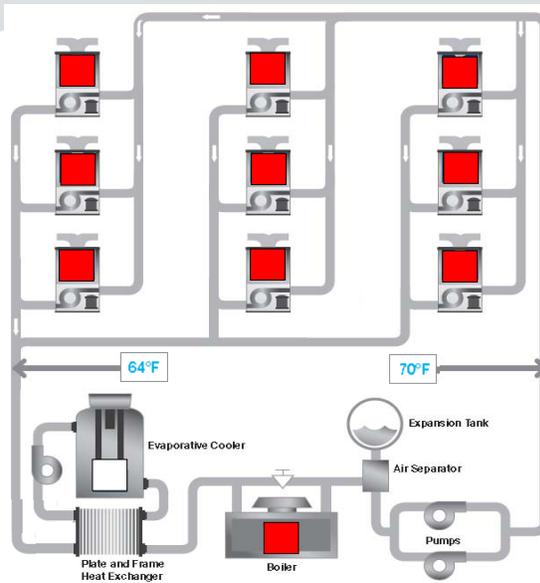


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DECENTRALIZED ADVANTAGES

Winter Heating Mode

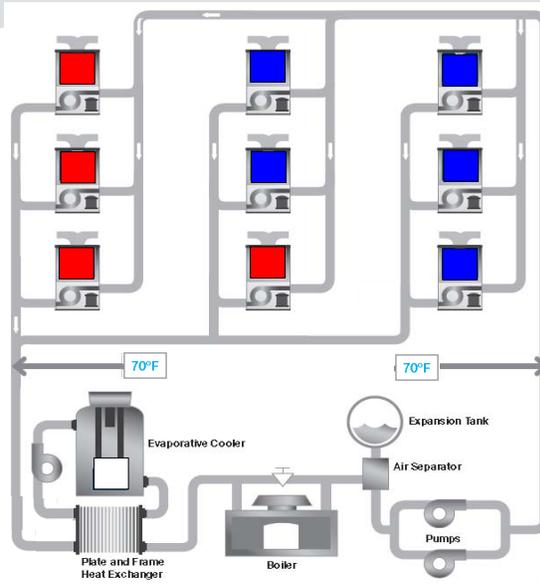


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DECENTRALIZED ADVANTAGES

**Intermediate
Season**

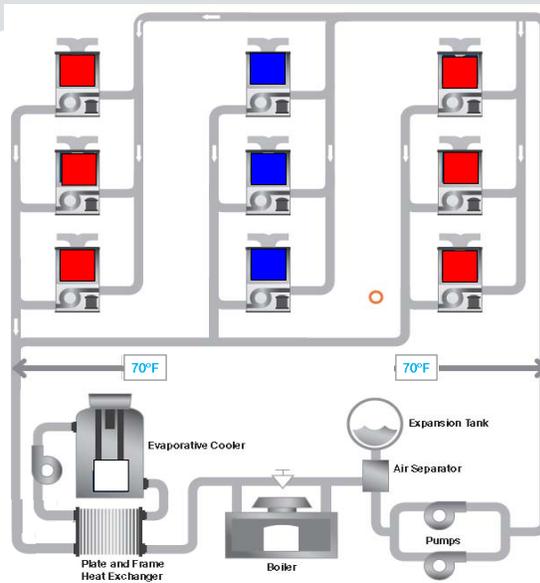


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DECENTRALIZED ADVANTAGES

**Heavy Interior
Loads
Core / Perimeter**



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Benefits Of A Geothermal Heat Pump

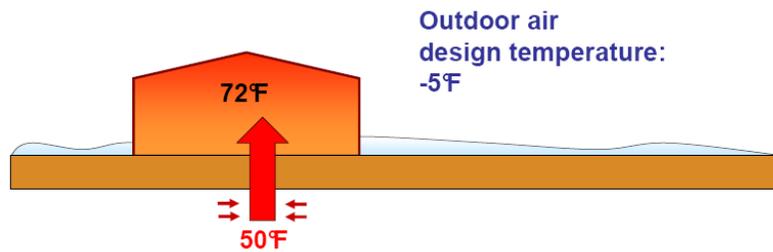


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Benefits Of A Geothermal Heat Pump

The Earth is a Source of Heat in Winter...

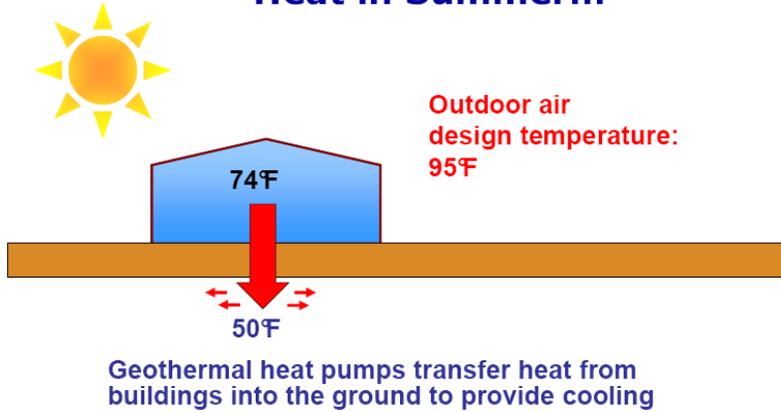


Geothermal heat pumps transfer underground heat into buildings to provide heating



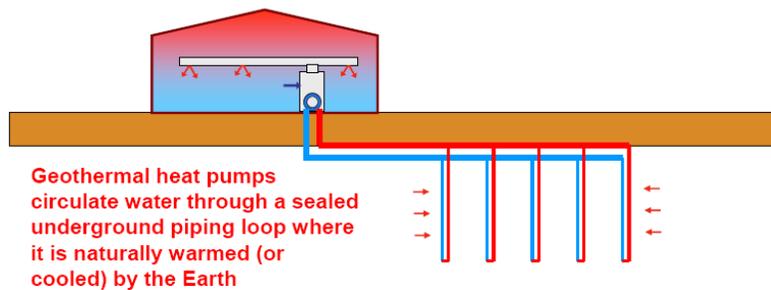
Benefits Of A Geothermal Heat Pump

...and an Efficient Place to Reject Heat in Summer...



Benefits Of A Geothermal Heat Pump

...using Heat Pump Technology





Geothermal / GeoExchange Loop Options

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Initial Site Evaluation

Open Loop – Well Water Application

Ground Water Pumped From Well.

Entering Water Temperatures 43 F To
75 F Degrees

Poor Water Quality Can Increase
Maintenance Costs

Costs = \$ (Cheapest Geo)
Maintenance = \$\$\$



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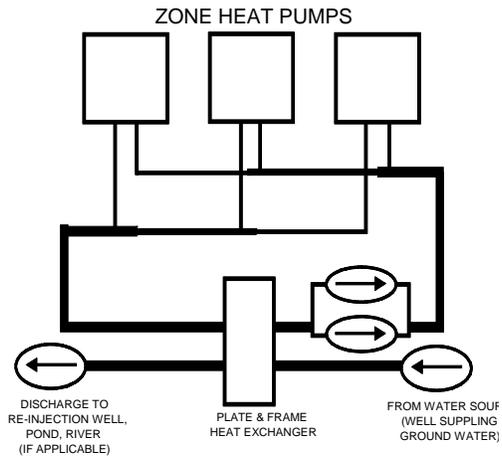
Initial Site Evaluation

Ground Water / Open Loop

Commercial Projects Use Heat Exchangers

Design For 2 GPM / Ton - Direct To Unit

Code May Require You To Discharge At Same Depth As Removed.



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Initial Site Evaluation

Vertical Closed Loop Earth Coupled

Bore Depths From 200 To 500 Feet

Commercial Bore Spacing 15 To 20 Feet Centers

Entering Water Temperatures 30 to 100 Degree F

Installed Costs = \$\$\$

Maintenance Costs = \$



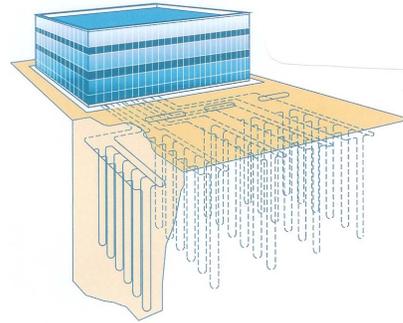
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Initial Site Evaluation

Vertical Closed Loop Earth Coupled

- Best Option For Limited Site
- Requires Approx. **250 Square Feet Of Surface Area** Per Ton
- Software Analysis Needed For Total Length
- Manifold Inside Building Or In Vault Outside Of Building (Header Pit)



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Initial Site Evaluation

Header Pit / Vault Outside Of Building

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Initial Site Evaluation



Typical Vault - Header Pit



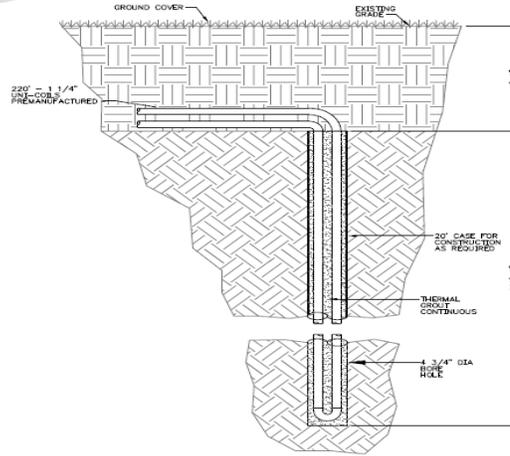
Initial Site Evaluation



“Run Out Piping “ From Manifold To Vertical Bore



Initial Site Evaluation



NOTE: THERMAL GROUT SHALL BE HIGH-SOLID BENTONITE.
 DETAIL - BORE HOLE 4
 2' 1' 0' 2'



Initial Site Evaluation

Plastic Pipe:

High Density Polyethylene (P.E. 3408)

- 1" Pipe for Bores 200 To 300 Feet Deep**
- 1 1/4" Pipe for Bores 250 To 400 Feet Deep**

2" - 12" Diameter PE pipe Is Used On All Piping From Header To Loop Field.



Pre-manufactured U-Bend with heat fused joints.

U-Bend Types





Initial Site Evaluation



Large "Fusion" Machine

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Initial Site Evaluation

Surface Water / Lake Loop

Entering Water Temperatures
35 To 87 Degrees F

Water Depth - Min. 10 To 12
Feet "Average Depth"

Installed Costs = \$\$

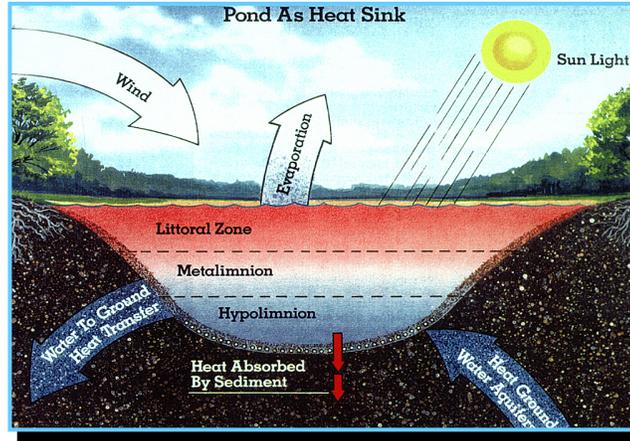
Maintenance Costs = \$



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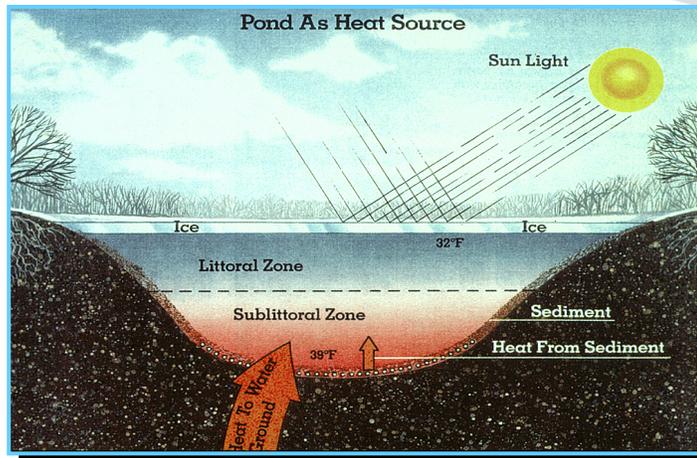
Initial Site Evaluation



Surface Water Lake Loop - Summer Evaporative Cooling



Initial Site Evaluation



Surface Water Lake Loop - Summer Evaporative Cooling



Initial Site Evaluation

Surface Water / Lake Loop



“Stainless Steel Heat Exchanger
• Available in Titanium

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Initial Site Evaluation

Horizontal Closed Loop

Trenches 3' To 5' Deep

**Deeper Than 5' May
Require Wall Supports**

**Entering Water
Temperatures 35 To 100
Degree F**

**Installed Costs = \$\$
Maintenance Costs = \$**



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Initial Site Evaluation

Horizontal Closed Loop

- Best For Unlimited Land Use
- Requires **2,500 Square Feet Surface Area** per Ton
- Usually 150 To 220 Of Trench Per Ton
- Software Analysis Needed

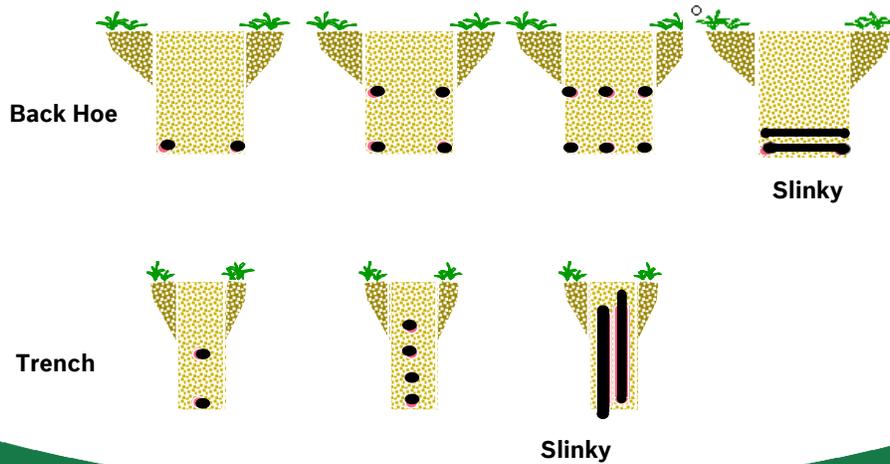


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Initial Site Evaluation

Horizontal Closed Loop



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System Comparisons and Economics

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Is Owners Decision Based On:

- A Full Life Cycle Study
- System Installed Cost Only
- Energy Savings Only

Are There “Alternative Energy” Considerations

- LEED
- Carbon Credits



What Are The Owners Priorities ?

- **What Is The Expectation Of Simple Payback**
 - ***3 Years – 10 Years?***
- **Expectation Of Operating / Maintenance Costs**
 - ***Expecting A 20% Or 60 % Savings?***
- **Is There A Green Requirement?**
 - ***LEED Or Owner Preference***



Determine Comparable HVAC Systems

- **Geothermal Vertical / Horizontal / Surface Water**
- **Geothermal Open loop**
- **VAV – Water Cooled w/ Boiler**
- **VAV – Air Cooled w/ Boiler**
- **Fan Coil WCC w/ Boiler**
- **Fan Coil ACC w / Boiler**
- **Rooftop Gas / Electric**



Installed Costs (US Estimated Range 2009)

- Geothermal Vertical **\$16 to \$23** per sq. / ft.
- Geothermal Horizontal \$13 to \$17 per sq. / ft.
- Geothermal Surface Water \$13 to \$16 per sq. / ft.
- Geothermal Vertical / Hybrid \$14 to \$18 per sq. / ft.
- VAV – Water Cooled w/ Boiler **\$16 to \$20** per sq. / ft.
- VAV – Air Cooled w/ Boiler \$14 to \$18 per sq. / ft.
- Fan Coil WCC w/ Boiler \$12 to \$16 per sq. / ft.
- Fan Coil ACC w/ Boiler \$12 to \$16 per sq. / ft.
- Rooftop Gas / Electric \$10 to \$16 per sq. / ft.

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Maintenance Costs (Estimate 2009)

- Geothermal Vertical **\$.11 to \$.22** per sq. / ft.
- Geothermal Horizontal \$.11 to \$.22 per sq. / ft.
- Geothermal Surface Water \$.11 to \$.22 per sq. / ft.
- Geothermal Hybrid – Tower \$.18 to \$.30 per sq. / ft.
- VAV – Water Cooled w/ Boiler **\$.25 to \$.40** per sq. / ft.
- VAV – Air Cooled w/ Boiler \$.20 to \$.35 per sq. / ft.
- Fan Coil WCC w/ Boiler \$.25 to \$.29 per sq. / ft.
- Fan Coil ACC w/ Boiler \$.20 to \$.25 per sq. / ft.
- Rooftop Gas / Electric \$.35 to \$.55 per sq. / ft.

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Life Cycle Study Most Commonly Used Software

- System Analyzer / Trace 700
- eQUEST
- HAP
- Energy Plus
- EnergyPro – California (Title 24)



System Analyzer Example for Cincinnati

System 1

System 2

Cincinnati Home

General [f](#) [Edit](#) Weather [Edit](#)

Building Owner RBNA Location Cincinnati, Ohio

Application User Howard Newton Economic Information [Edit](#)

Available Alternatives [Create a new alternative...](#)

Alternative 1 [f](#) [\\$](#) Chilled Water / Hydronic Heat [Edit](#) | [Delete](#)

Alternative 2 [f](#) [\\$](#) Geothermal Heat Pump - Ground Coupled [Edit](#) | [Delete](#)

VAV

Geothermal



System Analyzer Example for Cincinnati

Utility Costs
kWh - \$0.07
kW - \$15.00
NG - \$0.95 / therm

Alternative 1 Costs

Costs Undo Changes

Equipment Cost		Economic Info	
Equipment Installed Cost	20 \$/sq ft	Study Life (Yrs)	20
Additional First Cost	0 \$	Mortgage Life (Yrs)	20
Yearly Maintenance Expense	0.3 \$/sq ft	Depreciation Life (Yrs)	20
Revenue Penalty	0 \$	Mortgage Interest Rate (%)	10
Recurring/Additional Depreciable Cost		Percent Financed (%)	0
Cost	0 \$	Declining Balance Taxes (%)	100
Year Cost Incurred	0	Income Tax Rate (%)	0
Economic Life	0 Years	Cost of Capital (%)	10
Depreciation Life Taxes	0 Years	Depreciation Tax Method	None
		Maintenance Rate (%)	5
		Utility Rate (%)	5
		Replacement Cost (%)	5
		Comparison Base Alternative	Lowest cost



System # 1
VAV Maintenance Costs = .30 sq / ft.

System # 1
VAV Installed Costs = \$20.00 sq / ft.



System Analyzer Example for Cincinnati

Alternative 2 Costs

Costs Undo Changes

Equipment Cost		Economic Info	
Equipment Installed Cost	23 \$/sq ft	Study Life (Yrs)	20
Additional First Cost	0 \$	Mortgage Life (Yrs)	20
Yearly Maintenance Expense	0.19 \$/sq ft	Depreciation Life (Yrs)	20
Revenue Penalty	0 \$	Mortgage Interest Rate (%)	10
Recurring/Additional Depreciable Cost		Percent Financed (%)	0
Cost	0 \$	Declining Balance Taxes (%)	100
Year Cost Incurred	0	Income Tax Rate (%)	0
Economic Life	0 Years	Cost of Capital (%)	10
Depreciation Life Taxes	0 Years	Depreciation Tax Method	None
		Maintenance Rate (%)	5
		Utility Rate (%)	5
		Replacement Cost (%)	5
		Comparison Base Alternative	Lowest cost



System # 2
Geo Maintenance Costs = \$.19 sq / ft.

System # 2
Geo Installed Costs = \$23.00 sq / ft.



System Analyzer Example for Cincinnati

Economic Comparison Report

Alternative		Cost Summary				Life Cycle Cost
Number	Installed Cost	First Year Utility Cost	Final Year Utility Cost	First Year Maint. Cost	Final Year Maint. Cost	
1	\$ 1,200,000	\$ 155,975	\$ 455,369	\$ 25,000	\$ 20,647	\$ 4,143,228
2	\$ 1,840,000	\$ 152,036	\$ 364,187	\$ 15,200	\$ 38,410	\$ 3,865,575

Alternative Comparison		Comparison	Alternative
Comparison	First Cost Difference	Life Cycle Cost Difference	Simple Payback
Alt 2 vs 1	\$ 240,000	\$ 277,653	5.6 yrs

Alt 2 vs 1		Comparison	Alternative
Comparison	First Cost Difference	Life Cycle Cost Difference	Net Present Value
Alt 2 vs 1	\$ 240,000	\$ 277,653	\$ 277,653

Year	Cash Flow Difference	Cumulative Cash Flow Difference	Present Value of Cash Flow Difference	Net Present Value
0	-240,000	-240,000	-240,000	-240,000
1	42,739	-197,261	38,853	-201,147
2	44,676	-152,585	37,087	-164,060
3	47,119	-105,267	35,401	-128,659
4	48,675	-55,791	33,792	-94,866
5	51,949	-3,842	32,256	-62,610
6	54,648	30,704	30,790	-31,820
7	57,274	107,978	29,391	-2,429
8	60,137	188,115	28,055	25,226
9	63,144	231,260	26,778	52,005
10	66,302	297,561	25,562	77,567
11	69,617	387,178	24,400	102,367
12	73,097	440,275	23,291	126,658
13	76,752	517,028	22,232	147,891
14	80,590	607,618	21,222	168,113
15	84,619	682,237	20,257	189,370
16	88,650	771,088	19,336	208,705
17	93,293	864,381	18,458	227,164
18	97,958	962,338	17,618	244,722
19	102,855	1,065,194	16,818	261,600
20	107,998	1,173,192	16,053	277,853

Life Cycle Costs

VAV = \$4,143,228

Geo = \$3,865,575

Simple Payback = 5.6 years

Net Present Value = \$277,653

Internal Rate of Return = 21.9 %



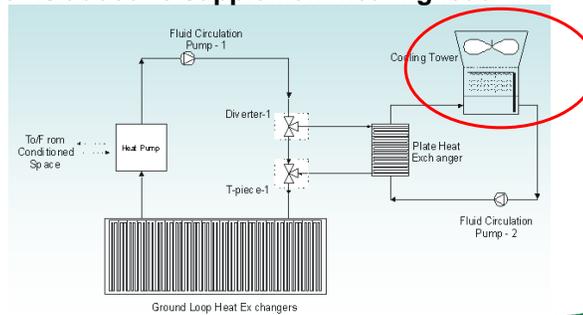
Hybrid Geothermal Design



What Is A “Hybrid” Design

Hybrid Design is a “Low Cost” alternative to a full GHP design

- **Southern & 24 / 7 applications** – Loop matches heat load and a cooling tower is added to assist rejection load
- **Northern applications** – Loop matches cooling load and a boiler is added to supplement heating load



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Why use a “Hybrid” Design?

A geothermal loop field designed for cooling may result in higher first costs and **unattractive short term economics.**

In Southern, Western and 24 / 7 applications, heat rejected from cooling may be **40 to 50 times** more heat than extracted during heating.

Some sites have unfavorable geological conditions or limited site available – a hybrid will reduce the area need for the loop field.

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Designing a “Hybrid Loop” – Cooling Mode

Rule of thumb – use hybrid where ground exceeds 60°F



- “Hybrid Software” determines new “shorter” loop length for total heating (and partial cooling) and sizes tower.



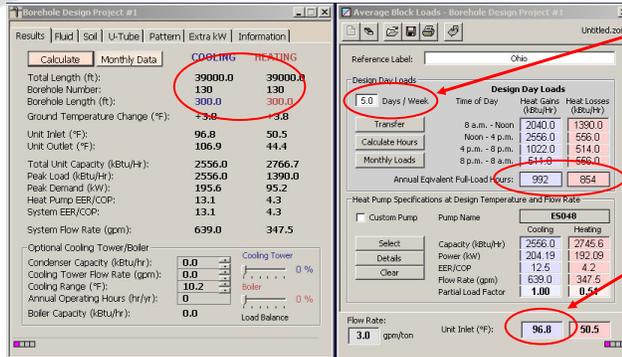
Hybrid Economic Example

Cincinnati Example



Cincinnati Building with "Similar" Heating and Cooling Equivalent Full load Hours - 5 Days / week

Building Cooling Load = 250 tons connected / 213 Block



5 Days a week

992 cooling EFLH
854 heating EFLH

96.8 EWT Max
(Acceptable Design)

Requires 130 bores @ 300 feet

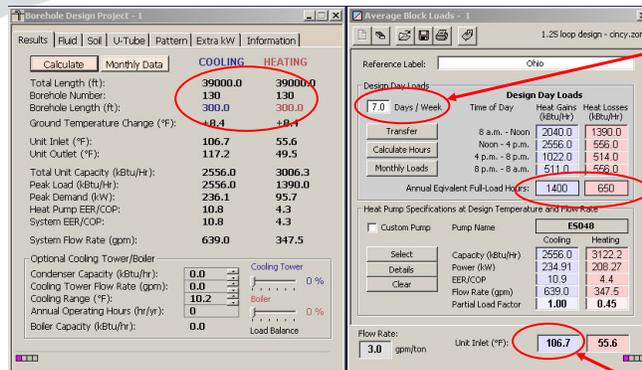
(1.25" PE pipe / 5" dia bore hole / .85 eff. grout

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Cincinnati Building with "Heavy" Cooling Equivalent Full load Hours - 7 Days / week

Building Cooling Load = 250 tons connected / 213 Block



Changed to
7 Days a week

Increased EFLH:
1400 cooling EFLH
650 heating EFLH

Same 130 bores @ 300 feet

(1.25" PE pipe / 5" dia bore hole / .85 eff. Grout)

106 EWT Max
(Units will
shut down)

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Cincinnati Building with "Heavy" Cooling Equivalent Full load Hours – 7 Days / week

Building Cooling Load = 250 tons connected / 213 Block

**Solution:
Increase to
160 Bores**

**95 EWT Max
(New temp with
added bore holes)**

- Add 30 extra bore holes x 300 feet = 9,000 feet of bore
- or **\$126,000 @ \$14 / foot**

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Cincinnati Building using "Hybrid Design" Ground Loop

Building Cooling Load = 250 tons connected / 213 Block

**Tower and loop
have max temp of
94 EWT**

Hybrid Design Solution / Ground Loop and Cooling Tower

- Requires **130 bores @ 300 feet** (1" PE pipe / 5"dia bore hole / .85 eff. Grout)
- Add Cooling Tower with Capacity = 613,000 /Btuh (50 ton)
- Saves \$126,000 installed costs over full loop design + Tower costs

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FHP “GREEN” Product Line

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FHP Bosch Group

Thermotechnology Division

Fort Lauderdale, Florida



Major Manufacturer of “Water Source Heat Pump” Products

- Heating and Cooling Units
- Boiler / Tower Applications and Geothermal applications
- Complete product line of “Green” 410A Refrigerant
- Commercial and Residential Product
- Marketing worldwide – 50 & 60 cycle

Bosch Thermotechnology: WSHP (FHP Bosch Group), Bosch Solar Collectors, Buderus Boiler, Bosch Instantaneous Water heater

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Models Sizes, Geo, ECM Motor, HGRH & Elec Heat

Product Line

July 2011

Model	Configuration	Size Range	Efficiency	Ext. Range	ECM Fan Motor	Hot Gas Reheat	Electric Heat
EC	H, V, S, D	½-30 tons	Std.	Optional	No**	Optional	No
EP	H, V	½-6 tons	Premium	Optional	015 >=	Optional	No
ES	H, V, S, D	1½-6 tons	High	Std.	Std.	Optional	Optional
ES 2-Stage	H, V, S, D	2-6 tons	High	Std.	Std.	Optional	Optional
AP	H, V, S, D	2-6 tons	Ultra-High	Std.	Std.	No	Optional
MC	Large Vertical	30-60 tons	High	Std.	VFD opt.	Optional	No
CA	Console	¾-1½ tons	High	Std.	No	No	No
WW	Water-to-Water	2-35 tons	High	Std.	---	--	---
TRS	Mixed Air Rooftop	3-35 tons	Std.	Optional	VFD opt.	Optional	Optional
RT	100% OA Horiz. Indoor / Rooftop	1k-10k CFM/ 4-30 Tons	Std.	Std.	VFD opt.	Optional	Optional

H = Horizontal V = Vertical S = Split System D = Downflow (Counterflow)

ALL units refrigerant HFC-410a

** VFD optional on EC120 and >, verticals only.

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Small Horizontal Units - ½ to 6 tons



EC Series	½ to 6 tons
ES Series	1½ to 6 tons
EP Series	½ to 6 tons
AP Series	2 to 6 tons

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Large Horizontal Units – 6 to 20 tons



EC Series

6 to 20 tons

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Horizontal Unit Installation



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Small Vertical Units - ½ to 6 tons

EC Series	½ to 6 tons
ES Series	1½ to 6 tons
EP Series	½ to 6 tons
AP Series	2-6 tons

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Vertical Unit
Installation



Large Vertical Units – 6 to 60 tons



EC/MC Series: 30 to 60 tons

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Console Units – ½ to 1½ tons



CA Series

¾ to 1 ½ tons

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R-410A Rooftop Units – 3 to 35 tons



TRS Series

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100% Outdoor Air Rooftop Heat Pump Units with Energy Recovery

100% Outdoor Air
R-410A Water Source Heat Pump
built-in Energy Recovery Wheel
1,000 to 10,000 CFM
4 to 30 Tons Cooling
Geothermal or Boiler/Tower
Modulating Hot Gas Reheat
Delivers Neutral Air
Optional DDC Controls
Optional CO₂ Sensing

Can be Mounted Outdoor or Indoors
Side-by-Side Airflow Patterns
Pre-engineered design for cost effective solution to outdoor air



RT Series

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Questions?

