The Blake Research Facility
East Windsor CT

4 different borehole heat exchangers, each with their own BTU meter.

Special manifolds allow mixing in total, or various combinations or total separation of loops.

All pipe is HDPE.
Typical Net BTU Values by Energy Source

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>BTU/$</th>
<th>BTU/$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>18,000</td>
<td>33,000</td>
</tr>
<tr>
<td>Electric</td>
<td>20,000</td>
<td>32,000</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>26,000</td>
<td>45,000</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>33,000</td>
<td>56,000</td>
</tr>
<tr>
<td>Wood / Coal</td>
<td>40,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Air Source Heat Pump</td>
<td>45,000</td>
<td>55,000</td>
</tr>
<tr>
<td>As-Built Geo-Exchange</td>
<td>45,000</td>
<td>75,000</td>
</tr>
<tr>
<td>IGSHPA Geo-Exchange</td>
<td>76,000</td>
<td>79,000</td>
</tr>
<tr>
<td>Advanced Geo-Exchange</td>
<td>90,000</td>
<td>220,000</td>
</tr>
</tbody>
</table>

Commonly found BTU/$ value during forensic engineering review

Value we have obtained

55 Apartments
62,850 Sq-Ft
8 btu/sf @ -20ºF
(41.6 Tons)
All HVAC = 19.7 Kbtu/SF/Yr
24 500' GPX U-Tubes
Typical Dual Mode
Chiller Load 12 to 16 Tons Heating with 3 to 9 Tons Cooling

R.C.C. > Exceptional BTU/$ & Smallest Carbon Footprint
Potential reduction in operating KWH

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-Air vs DX-Air</td>
<td>15% to 30%</td>
</tr>
<tr>
<td>PSC pump vs ECM pump</td>
<td>15% to 80%</td>
</tr>
<tr>
<td>Advanced Borehole HX’s</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>Methanol &amp; Glycol Mixture vs 30% Glycol</td>
<td>5% to 15%</td>
</tr>
<tr>
<td>VFD Pump vs ECM pump</td>
<td>8% to 10%</td>
</tr>
<tr>
<td>Compressor type: Mag bearing vs scroll compressor</td>
<td>50% to 100%</td>
</tr>
<tr>
<td>Thermal Solar Hybrid integration</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>Larger Pipe size selection</td>
<td>10% to 30%</td>
</tr>
</tbody>
</table>

THE ENERGY INDEPENDENCE PIE

- Alternative Energy Harvesting
- Energy Recycling
- High Efficiency Cooling

Save 50% to 60% on your operating costs

Keys to Success for N.N.Z.E.

- Air Sealed Building Construction > Blower door testing
- Low Source to load delta T > Better G.S. H/X > Load Coils
- Cost efficient pumping > ECM > Push Pull > Low Head
- Hybrid Designs: > + Thermal Solar > – Dry Coolers
- Buffer tank Design > Direct to Load Configuration
- Piping Materials: > HDPE > Self Insulating
Enhanced thermal conductivity HDPE pipe can reduce the required borehole length for a geo-exchange field by 10% to 40%.

The pipe has a greater advantage in buildings that cool by day and heat by night. "Put and take" Geo-Exchange
Geo-Exchange: Heat Exchanger Basic Comparison

Comparison of borefield designs at an equal system heat pump operating efficiency

3.5
500’ 1-1/4”Ø HDPE U-TUBE BOREHOLES

= 10 Tons +/-

1,100’ 5”Ø HDPE CONCENTRIC

= 1 bed

150’ x 50.6’
10,000 LF Thermally Enhanced HDPE TUBE

HDPE Vs. Graphite Enhanced HDPE

133 Tons +/-

40
500’ 1-1/4”Ø HDPE U-TUBE BOREHOLES

= 20,000’ DRILLED LENGTH

34
450’ (4) 2’4”Ø Twister BOREHOLES

= 15,300’ DRILLED LENGTH

18
800’ (2) 1-1/2”Ø GPX Double U BOREHOLES

= 14,000’ DRILLED LENGTH

8
1,540’ (4) 3/4”Ø GPX Single BOREHOLES

= 12,300’ DRILLED LENGTH

Twin Loop: 1-1/4” or 1-1/2”

The Double U-Bend

15% to 40% less drilled length required
Each of the 4 zones are balanced to deliver the same return water temperature from a matched set of identical horizontal geo-exchange beds.

The 2 left flow meters connect to a total of 3000' of ¾” GeoperformX Thermally Enhanced DR11 HDPE, Balanced to 16 GPM producing 32,000btu/hr (Ti=37°F, To= 41°F)

The 2 right flow meters connect to a total of 3000' of ¾” PE-3608 DR-11 HDPE, Balanced to 8 GPM producing 16,000btu/hr (Ti=37°F, To= 41°F)
Horizontal Header - Racetrack Bed
Race track & Header = 90% savings in Pumping HP over slinky design

More Multi-Source Geo

Centralized In-Slab Header: Radiant Heat or Cooling
¾” Thermally Enhanced Tube, spaced as required to meet load requirements
Magnetic Bearing Near Frictionless Compressor
SEER of 18 to 28 & COP of 6 to 11

Oil Free Compressors...
- Ultra High Efficiency Chillers
- Heating COP > 8 to 14
- Cooling EER >27 to 47
- Unloadable to 20% before HGBP

Hydronic Efficiency Buffer Tanks Direct to Load Piping

Buffer tank / Hydronic separator piped in bypass configuration reduces compressor power by 10% to 15%

ECM PUMPS - HIGHEST WIRE TO WATER PUMP EFFICIENCY

Single Phase Capacitor start
3 speed selectable
+11% to +80% KWH

E.C.M.
Higher torque per watt
DC Permanent Magnet
Variable Speed Motor

+8% to +20% +/- KWH
ECM variable speed
Push – Pull
35’ to 45’ Head
Save $35K/ station

Old School:
parallel redundant pumps
60 to 125’ Head
Separate VFD
Pump KW = Pipe Velocity³

Parasitic Pump Power vs COP Efficiency

Designs using the 1-1/2” GPX2 Twin-Loop use the same 27’ head loss target but for 7-1/2 ton per borehole

2.8 ton per borehole
2.8 ton / 7 1/2 tons
3.0 ton / 150 tons

Do’s and Don’ts

½” to 6” self controlling balance valve
Allows full bypass flow for cleaning and air purge

Many variations of auto balance valves, all require individual service to clean each valve of debris.
No bypass for air purge.
4 Pipe
Ductless Heating and Cooling

Ceiling Mount

Wall Mount

3 modes - Never Mixes
- Proportional Heating
- Off
- Proportional Cooling

Propylene Glycol Losses

For a 30% mixture of propylene glycol for freeze protection to 27°F outlet from the heat pump.

- Added flow GPM required = 10% - 15%
- Added head loss = 7% - 10%
- Added pump H.P. = 25% - 30%
- Added cost of chemical and replacement

Pump run time hours can often exceed compressor run time hours by 50% making added pump H.P. very costly for yearly operating costs.

GeoExchange Water Room
HDPE Fusion Pipe

4 Fusion Methods

Geo Headers Do’s and Don’ts

HDPE true union
Butt Fusion Valves
× Ferrous Flange & Valves
✓ Visual Flow Meters
   (Or DDC Meters)
× Indicating Thermometers
✓ DDC sensors

Seabury

Original Basis of Design
96 600’ 1-1/4” U-Bend

V.E. Re-Design:
35 Geоперform-X 900’ Deep
DR11 1-1/2” Twin Loop

Savings to Owner = $250,000
**Choate Rosemary Hall Case Study**

Design Temperature: 50°F / 84°F
60 500’ 1-1/4” U-Bend
V.E. Re-Design:
40 500’ 1-1/4” HDPE U-Bend OR
15 Geoperform-X 900’ Deep DR11
1-1/2” Twin Loop

Savings to Owner = $300,000

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**The Community Music School of Springfield, MA Case Study**

Urban City Location
Available area: Side Alley
Deep Borehole H/X Design
6 Geoperform-X
1,100’ Deep
DR17 4” x 2” Concentric BHE
Grout ONLY top 100’

Design Temperature: 50°F/75°F

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**Excessive Parasitic Pump Power**

Distributed heat pumps,
45’ max head design vs 165’
Value Engineering Savings = $225,000

Value Engineering Savings = $300,000

Pre-Engineered water rooms for ground mount, retrofit penthouse or packaged skids for your mechanical room

Prefabricated Package may Include:

- Modular compressor units, 7, 15, 60, 90 tons each
- On board ECM Push-Pull pumping for HW, CHW, GEO
- Combination Buffer Tank / Hydronic Separator
- DDC package, Open Source BACnet
- Single Point Electrical Connection
- Units over 165 tons w/ magnetic bearing compressors
- Continually Self Balancing Geo Return Manifold
- Multi-Source Geo Hybrid Air-Source Options
Questions?

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Near Net Zero Energy HVAC by Design:
We look forward to working with you.

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Syracuse NY
Albany NY
Rutland VT
Greenfield MA
Hermon ME
Portland ME