About SES

Incorporated in 1997

Provide professional engineering services

Completed our first GeoExchange project in 1999

Experts in GeoExchange design and implementation

Moved into new office Jan. 2009

20 Ton GeoExchange system

Attempting LEED Gold certification

Who we are. What we do.
Overview

GeoExchange Systems:
- Vertical GHX
- Horizontal GHX

Design Approach

Lessons Learned

- Administration & Services Center
- Rolland – Warner Middle School
- Zemmer Middle School
Project Summary

Administration & Services Center

Typical 1950’s Elementary School

Project completed in February 2008

26,000 total square foot of building area

Home of district administration offices

ICS

Strategic Energy Solutions
Rolland–Warner Middle School

Project Summary
First Middle School in District
Project completed September 2009
Combination renovation & addition
119,000 total square foot of building area
Zemmer Middle School

Project Summary

Second Middle School in District

Project completion scheduled for September 2010

Combination renovation & addition

114,000 total square foot of building area
GeoExchange System Administration & Service Center

System Facts:

Vertical Borehole
Ground Heat Exchanger

35 Bore holes
300 feet each

Supply/Return manifolds located inside building

Central pumping system with VFDs
GeoExchange System
Rolland-Warner Middle School

System Facts:

20 Circuits total
10 Slinky/circuit

179,900 total ft. of slinky pipe

Supply/Return manifolds located in concrete vault

Hybrid system with two ultra-high efficiency condensing boilers

Central pumping system with VFDs
GeoExchange System
Zemmer Middle School

**System Facts:**

20 Circuits total
10 slinky/circuit

111,420 total ft. of slinky pipe

Supply/Return manifolds located in concrete vault

Hybrid system with two ultra-high efficiency condensing boilers

Central Pumping with VFDs
Design Points:

- 21 ground source heat pumps
- 7 heat pumps w/ supplemental electric heaters
- Most heat pumps located in existing closet space
- 2 Indoor ERVs with electric pre-heat

Design & Layout
Administration & Service Center

Renovated Space

Vertical GHX
Design Points:

Existing closet space used for heat pumps

Return air louvers cut into existing doors

Condensate pumps used to dispose of condensate waste
Design Points:
75 ground source heat pumps total

Combination of vertical and horizontal heat pumps

5 Custom roof mounted heat pumps

5 Standard roof mounted ERVs with electric pre-heaters
Design Points:

Classroom heat pumps installed in closets

Minimizes sound transmission

Allows for easier maintenance

Other heat pumps installed in existing mechanical rooms
Design Points:

- 80 Heat pumps total
- Combination of vertical and horizontal heat pumps
- 4 Custom roof mounted heat pumps
- 5 Standard roof mounted ERV’s with electric pre-heat

Design & Layout
Zemmer Middle School

- Horizontal GHX
- Vault
- 10” Mains
- Renovation
- Addition
Design Points:

Classroom heat pumps installed in closets

Minimizes sound transmission

Allows for easier maintenance

Other heat pumps installed in existing mechanical rooms
A “Must Use” For GeoExchange

Standard Units:
Energy recovery wheel with optional electric pre-heat

Custom Units: Units with different heat exchanger options:
- Wheel
- Plate and frame
- Dehumidification

Can incorporate geothermal ground source heat pump into unit
## Project Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Administration &amp; Services Center</th>
<th>Rolland – Warner Middle School</th>
<th>Zemmer Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Heat Exchanger</td>
<td>$144,000</td>
<td>$367,000</td>
<td>$260,250</td>
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<tr>
<td>GHX - Cost / SF</td>
<td>$5.54</td>
<td>$3.08</td>
<td>$2.28</td>
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<tr>
<td>Mechanical</td>
<td>$360,000</td>
<td>$3,784,520*</td>
<td>$2,696,750*</td>
</tr>
<tr>
<td>Mechanical – Cost / SF</td>
<td>$13.85</td>
<td>$31.80</td>
<td>$23.66</td>
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<tr>
<td>Overall System</td>
<td>$504,000</td>
<td>$4,151,520</td>
<td>$2,957,000</td>
</tr>
<tr>
<td>Overall System – Cost / SF</td>
<td>$19.38</td>
<td>$34.89</td>
<td>$25.94</td>
</tr>
</tbody>
</table>

* Includes project plumbing costs
Statistical Data

Actual Energy Savings
Administrative & Services Center
Monthly Energy Cost

Before After

January '04 March May July September November

January '05 March May July September November

January '06 March May July September November

January '07 March May July September November

January '08 March May July September November

Statistical energy cost
Monthly energy cost

January '04 March May July September November

January '05 March May July September November

January '06 March May July September November

January '07 March May July September November

January '08 March May July September November

Strategic Energy Solutions
SES Design Approach & Process

Process

Owners Project Requirements (OPR)

Basis of Design (BOD)
Process

Performed at Administration & Services Center

Formation Thermal Conductivity Testing

Figure 1: Temperature versus Time Data

Strategic Energy Solutions
SES Geothermal Design Approach

Process

- Carrier’s Hourly Analysis Program (HAP)
- Microsoft Excel
- Trane Trace
- Gaia’s Ground Loop Design (GLD)

Diagram:
- Carrier HAP
- Microsoft Excel
- Trane Trace
- Gaia’s Ground Loop Design Software

Strategic Energy Solutions
**Process Simulation Output vs. Check Figures**

**Zemmer M.S. Simulation Hourly Output**

**Peak heating:**
- 2,600 MBH Total
- 1,872 MBH Geo
- 728 MBH Boiler

**BTU/square foot**
- 24 BTU/SF

**Peak Cooling:**
- 2,300 MBH Total
- 594 SF/Ton

**Hourly run times**
- Cooling: 575
- Heating: 1112

**Hourly Analysis Program (HAP) hourly graph**

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**WSHP Cooling Coil Load (MBH)**

**WSHP Heating Coil Load (MBH)**
# Ground Loop Design (GLD)

## Output Data

**Output Data Ground Loop Design (GLD)**

- **Total Trench Length (ft):** 12934.7
- **Single Trench Length (ft):** 64.7
- **Unit Inlet (°F):** 90.0
- **Unit Outlet (°F):** 100.4

## Design Method

- **Fixed Temperature**
  - **Inlet Temperatures:** 90.0 °F, 30.0 °F

## Configuration

- **Trench Number:** 200
- **Separation:** 4.0 ft
- **Depth:** 8.0 ft
- **Width:** 36.0 in

## Cooling Tower/Boiler

- **Condenser Capacity (kBtu/hr):** 0.0
- **Cooling Tower Flow Rate (gpm):** 0.0
- **Cooling Range (°F):** 10.8
- **Annual Operating Hours (hr/yr):** 0
- **Boiler Capacity (kBtu/hr):** 724.1

## Results

<table>
<thead>
<tr>
<th></th>
<th>COOLING</th>
<th>HEATING</th>
</tr>
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<tbody>
<tr>
<td>Total Trench Length (ft):</td>
<td>12934.7</td>
<td>13453.2</td>
</tr>
<tr>
<td>Trench Number:</td>
<td>200</td>
<td>200</td>
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<tr>
<td>Single Trench Length (ft):</td>
<td>64.7</td>
<td>67.3</td>
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<tr>
<td>Total Pipe Length (ft):</td>
<td>107123.6</td>
<td>111410.1</td>
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<tr>
<td>Single Trench Pipe Length (ft):</td>
<td>535.6</td>
<td>557.1</td>
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<tr>
<td>Unit Inlet (°F):</td>
<td>90.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Unit Outlet (°F):</td>
<td>100.4</td>
<td>20.7</td>
</tr>
<tr>
<td>Total Unit Capacity (kBtu/hr):</td>
<td>605.1</td>
<td>464.4</td>
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<tr>
<td>Peak Load (kBtu/hr):</td>
<td>2295.0</td>
<td>2586.0</td>
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<tr>
<td>Peak Demand (kW):</td>
<td>115.0</td>
<td>100.2</td>
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<tr>
<td>Heat Pump EER/COP:</td>
<td>13.4</td>
<td>3.2</td>
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<tr>
<td>System EER/COP:</td>
<td>20.0</td>
<td>7.6</td>
</tr>
<tr>
<td>System Flow Rate (gpm):</td>
<td>478.1</td>
<td>538.8</td>
</tr>
</tbody>
</table>

**Strategic Energy Solutions**
Ground Loop Design (GLD)
Earth Temperature over 10 years

Monthly Results

- Minimum EWT
- Maximum EWT

Temperature (°F)

Time (Months)

Strategic Energy Solutions
Ground Loop Design (GLD)

Calculation Results

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<td>111418.1</td>
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<tr>
<td>Single Trench Pipe Length (ft):</td>
<td>638.6</td>
<td>657.1</td>
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<tr>
<td>Peak Demand (kW):</td>
<td>138.3</td>
<td>123.5</td>
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<tr>
<td>Heat Pump EER/COP:</td>
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<tr>
<td>System EER/COP:</td>
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<td>6.1</td>
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<tr>
<td>System Flow Rate (gpm):</td>
<td>478.1</td>
<td>538.8</td>
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Input Parameters

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Flow Rate</th>
<th>Fluid</th>
<th>Specific Heat (°F°R/h°Btu)</th>
<th>Density (ρ):</th>
<th>Flow Type</th>
<th>Prediction Time:</th>
<th>Long Term Soil Temperatures:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5 gpm/ton</td>
<td>18.5% Propylene Glycol</td>
<td>0.97 Btu/(°F°h°Btu)</td>
<td>65.5 lb/ft³</td>
<td>Turbulent</td>
<td>10.0 years</td>
<td>Cooling: 57.2 °F Heating: 57 °F</td>
</tr>
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</table>

Pipe Configuration in Trench

<table>
<thead>
<tr>
<th>Pipe Type</th>
<th>Piping</th>
<th>Modeling Time Period</th>
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<tbody>
<tr>
<td>1 in (25 mm) SDR11</td>
<td></td>
<td>10.0 years</td>
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</table>

Optional Boiler/Cooling Tower

- Load Balance: 0 %
- Capacity (kBtu/Hr): 0.0
- Cooling Tower Flow Rate (gpm): 0.0
- Cooling Tower Heat Gain (°F): 10.8
- Annual Operating Hours (hr/y): 0

Load File

- Cooling Tower Pump: 0.0 kW
- Cooling Tower Fan: 0.0 kW
- Additional Process: 0.0 kW
**SES Lessons Learned**

- Throw the Old “Rules of Thumb” out the window
- Importance of accurate building schedules for simulations
- Take care when sizing pipe to and from remote GHX – poor sizing can lead to excessive head loss
- Importance of heat pump specifications – Key features: ECM motors, Dehumidification
- Coordination of cooling coil condensate, disposal -Floor drains or pumps
- Air separator vs. combination air/dirt separator
- Coordination between temperature control supplier and heat pump manufacturer - commissioning
- Importance of due diligence with geothermal specifications
  Clear and thorough specs ensure fair bidding process
Lapeer Community Schools

An Engineering Perspective on GeoExchange Design

2009 IGSHPA Conference
Dallas, Texas