Ground-Source Heat Pump Case Study

MAPC - MassCEC
Clean Heating and Cooling Workshop

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Geothermal Project Example

- Design
- Installation
- Equivalent Fuel Cost
- Massachusetts Incentives
- Simple Payback
No Volcano Needed
Vertical Closed-Loop
Affordable Housing Non-Profit Project Example
Updating a 1980’s Affordable Housing Project

- 5-story brick building
- 59 residential units
- Conditioned living space approximately 42,500 sq. ft
- Limited insulation
- Existing heating is via electric baseboard
- Some window-mount air conditioners
Why Geothermal?

- Offers Greatest Comfort with lowest operation cost
- GSHPs have the lowest Carbon Footprint of any heating and cooling system
- Project Location is in a Flood Plain which restricts some conventional options
- Massachusetts Incentives offset most of the incremental cost of GSHP compared to the original WSHP plan
Additional Advantages

• Separate GSHPs allow independent heating and cooling of all spaces
• GSHPs have Zero Carbon Monoxide emissions
• GSHPs have available energy monitoring, remote control and operation telemetry
• Electrical use can be offset by renewable sources
Thermal Loads and Equipment Selection

• Heating and Cooling Loads Calculated by Industry Accepted Methods
  • Peak Heating Load: 551,000 Btu/hr
  • Peak Cooling Load: 487,000 Btu/hr
• Mixed single and dual speed GSHPs
• Total nominal capacity approximately 55-65 tons
Ground Source

- A series 24 of vertical bores to 450 feet
- Bores constructed with high thermal conductivity grout and HDPE pipe that are geothermal-specific
- A redundant, variable speed, pumping system provides circulation
- Automated valves control flow at each GSHP
- Loop circuit connection and flow balance is via a central vault/manifold
Incremental Cost
Operational and Carbon Savings
Incremental Cost of GSHP

- Existing conditioning is provided by electric baseboard and some window-mount air conditioners
- Renovation plans originally included a conventional system using water-source heat pumps with a boiler and cooling tower
- Estimated incremental cost of GSHP over WSHP is $348,000 or less
Fuel Cost and Carbon Footprint

- GSHPs have much lower ‘fuel’ cost than alternatives
- GSHPs have the lowest carbon footprint of the available options
- System will harvest 928,000,000 Btu of renewable thermal energy annually
- GSHPs have lower maintenance cost and longer service life than conventional alternatives further reducing operating cost
Reduction in ‘Fuel’ Cost

<table>
<thead>
<tr>
<th>System Type</th>
<th>Heating</th>
<th>Cooling</th>
<th>Total</th>
<th>vs. GSHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Source Heat Pump (GSHP)</td>
<td>$15,123.55</td>
<td>$3,371.71</td>
<td>$18,495.26</td>
<td></td>
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<tr>
<td>Resistance</td>
<td>$59,785.77</td>
<td>$4,551.12</td>
<td>$64,336.89</td>
<td>$45,841.63</td>
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<tr>
<td>ASHP</td>
<td>$33,998.21</td>
<td>$4,551.11</td>
<td>$38,549.32</td>
<td>$20,054.06</td>
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<tr>
<td>Natural Gas</td>
<td>$19,639.91</td>
<td>$4,551.12</td>
<td>$24,191.03</td>
<td>$5,695.76</td>
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<tr>
<td>Propane</td>
<td>$43,256.57</td>
<td>$4,551.12</td>
<td>$47,807.69</td>
<td>$29,312.43</td>
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<tr>
<td>Fuel Oil</td>
<td>$32,208.28</td>
<td>$4,551.12</td>
<td>$36,759.40</td>
<td>$18,264.14</td>
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</tbody>
</table>
Reduction in Carbon Footprint

Annual CO2 Emissions by Technology

- GSHP: 51.3 Tons
- RH: 178.4 Tons
- ASHP: 106.9 Tons
- Nat Gas: 95.9 Tons
- Propane: 108.8 Tons
- Fuel Oil: 146.5 Tons

Tons of CO2
Financial Incentives
Simple Payback
Applicable Incentives

- Federal Investment Tax Credit
- Accelerated Depreciation
- Energy Efficient Building Deduction
- MassCEC Base Grant
  - High Efficiency GSHP Adder
  - Municipal/Non-Profit Adder
  - Affordable Housing Adder
- AEC Program
- MassSave Incentives (in service area)
### Post-Incentive Net Project Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Pre-Incentive Incremental Cost</td>
<td>$348,000</td>
</tr>
<tr>
<td>MassCEC Grant (assumes 60% of Efficiency plus Non-profit and Affordable Housing adders)</td>
<td>($136,000)</td>
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<tr>
<td>AEC Income (PV of 10 years less brokerage fee)</td>
<td>($112,000)</td>
</tr>
<tr>
<td>MassSave Incentives</td>
<td>($TBD)</td>
</tr>
<tr>
<td>Post-Incentive Cost</td>
<td>$100,000</td>
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</table>
## Simple Payback

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Cost/Time</th>
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</thead>
<tbody>
<tr>
<td>Post-Incentive Incremental Cost</td>
<td>$100,000</td>
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<tr>
<td>Annual Fuel Savings v. Existing Electric RH</td>
<td>$45,800</td>
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<tr>
<td>Simple Payback v. Existing</td>
<td>2.2 Years</td>
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<tr>
<td>Annual Fuel Savings v. WSHP-Boiler-Cooling Tower</td>
<td>$18,300</td>
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<tr>
<td>Simple Payback v. WSHP</td>
<td>5.5 Years</td>
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Questions?

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Go Sox!
Telemetry Example
MY ENERGY USE

Rate per kWh (in dollars)
0.18

Update

Compare | Day | Week | Year

$234
$195
$156
$117
$78
$39
$0

*Note: Average and total includes previous 7 months (excluding current month).