Simulation and Optimization of Hybrid Geothermal Energy Systems Using Solar Thermal Collectors as a Supplemental Heat Source

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**Research Objective:** To reduce the required size and costs of ground heat exchangers for geothermal energy systems by adding supplemental heating via solar thermal collectors.

**Introduction/Motivation**
- Geothermal energy systems: 3-4 times more energy efficient than conventional furnaces
- Initial cost of geothermal systems (due to large ground heat exchanger requirements) limits adoption
- Often applied in places where heating loads exceed cooling loads

**Methodology**
- 20-year hourly simulation of baseline and hybrid systems
- Ground heat exchanger and solar collectors sized with optimization routines
- Six different system configurations considered including solar hot water systems and ground heat exchanger bypass

**Results**

**Conclusions**
- Simulation/optimization method resulted in sizing components so that ground temperatures stabilized compared to non-hybrid systems
- Hybrid systems reduce ground heat exchanger size requirements
- Cost-competitiveness of hybrid systems depends on drilling costs and solar collector costs

**Recommendations**
- Investigate effects of climate (e.g. temperatures, humidity, solar conditions) and load imbalance on effectiveness of hybrid systems
- Investigate effects of bypassing ground heat exchanger when high-temperature solar energy is available on solar loop and heat pump operational energy

**Economic Analysis**

<table>
<thead>
<tr>
<th>System Alternative</th>
<th>Description</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>System B</td>
<td>GCHP only</td>
<td>5.39%</td>
</tr>
<tr>
<td>System C</td>
<td>GCHP + Solar DHW</td>
<td>7.79%</td>
</tr>
<tr>
<td>System D</td>
<td>Hybrid GCHP + Solar DHW</td>
<td>8.63%</td>
</tr>
<tr>
<td>System E</td>
<td>Hybrid GCHP Only</td>
<td>11.29%</td>
</tr>
<tr>
<td>System F</td>
<td>Hybrid GCHP with 15%GHE Bypass + Solar DHW</td>
<td>6.39%</td>
</tr>
</tbody>
</table>

**TRNSYS Simulation**

**System Schematic**

**Annual Load Profile for Space Conditioning + Reduced DHW Loads**

Heating/Cooling Imbalance: 4:1