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

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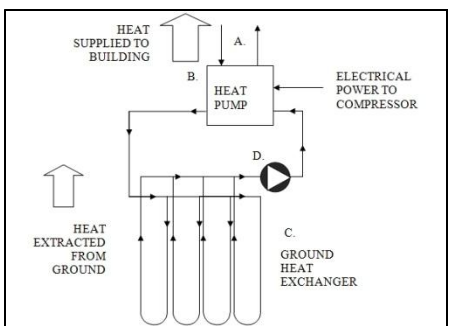
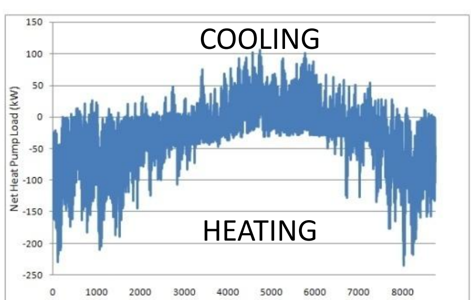
**Research Objective:** To reduce the required size and costs of ground heat exchangers for geothermal energy systems by adding supplemental heating via solar thermal collectors.

## 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




*Conceptual schematic of GCHP system showing major components. A – Building-side water loop or fan coil. B – Heat pump. C – Vertical borehole ground heat exchanger. D – Ground heat exchanger circulation pump.*

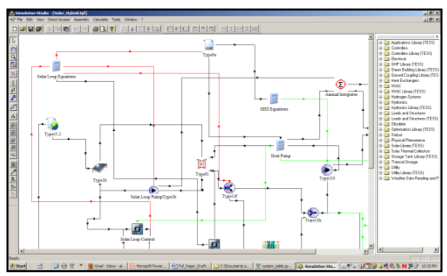



*Annual Load Profile for Space Conditioning + Reduced DHW Loads*

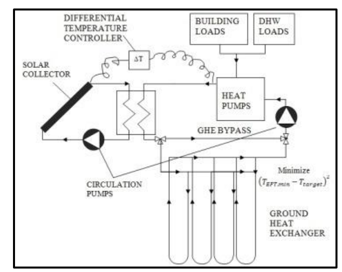
Heating/Cooling Imbalance: 4:1

## 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

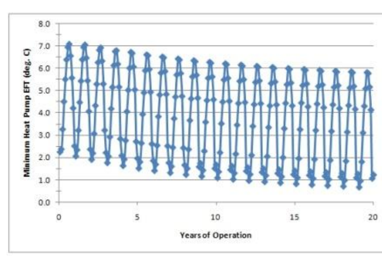


*TRNSYS Simulation*

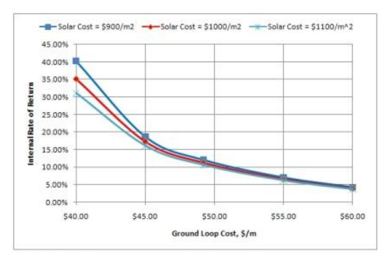



*System Schematic*

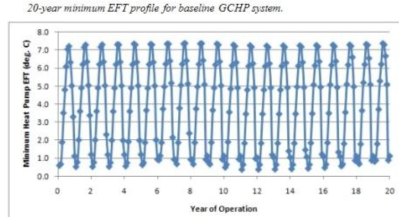
## Results



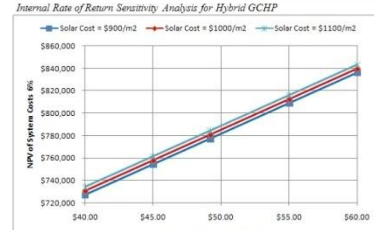

*20-year minimum EFT profile for baseline GCHP system.*




*Internal Rate of Return Sensitivity Analysis for Hybrid GCHP*




*20-year minimum EFT profile for hybrid GCHP system with ground-coupled solar only.*




*Net Present Value of lifecycle system costs at 6% discount rate for Hybrid GCHP*

## Economic Analysis

IRR Summary of System Alternatives

| System Alternative | Description | IRR |
|---|---|---|
| System B | GCHP only | 5.39% |
| System C | GCHP + Solar DHW | 5.79% |
| System D | Hybrid GCHP + Solar DHW | 6.63% |
| System E | Hybrid GCHP Only | 11.29% |
| System F | Hybrid GCHP with 25% GHE Bypass + Solar DHW | 6.39% |

## 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