Greensleeves LLC
Control of
Ground Source Heat Pump Systems
GSHPA Technical Seminar 2018
Greensleeves LLC
Overview Agenda
23rd May 2018

- What makes GSHP Different?
- “Simple” Full Load Systems
- Hybrid & Complex Systems
- How it Works
- Project Example
- Questions & Comments
What makes GSHP Different?
“Simple” Full Load Heating (or Cooling) Systems
Hybrid & Complex Systems
Example Project

- This is an actual project that has been installed and is currently operational – the name and location of the project is confidential at the request of the U.S. Government

- Conductivity was found to be 2.59 W/mK
- Ground temperature relatively warm at 20°C
- Cumulative building loads were extremely cooling dominant
- Limited land available for the Ground Loop
Greensleeves Hardware

DS-1002P

4th Gen. Intel® Core™ i3 / i5 / i7 Superior Performance Fanless Computer
Integrate Q87 Chipset, 2x PCI / PCIe Expansion, 4x PoE and 2x LAN

Key Features

- Support 4th Gen. Intel® Core™ i3 / i5 / i7 Desktop Processor (LGA1150) and Intel® Q87 Chipset
- 2x DDR3 / DDR3L 2048-DIMM Max. up to 16GB
- Three Independent Display from 1x DVI-I and 2x DisplayPort
- 6x Intel® GbE Port with 4x PoE Function, Support Wake-on-LAN and PXE
- 4x USB 3.0 and 4x USB 2.0
- 6x RS232/422/485 Port with 5V/12V Power
- 4x Isolated DI, 4x Isolated DO
- 2x 2.5” SATA SSD/HDD Bay, 2x mSATA (1x Shared by Mini-PCIe Socket), 1x CFast Card and 1x SIM Card Socket
- 9~48VDC Power Input, Support AT/ATX Mode
- 2x Mini-PCIe Slot for Wi-Fi, GSM, or I/O Expansion
- 2x PCI / 1x PCIe x1 and 1x PCIe x16 / 1x PCI and 1x PCIe x16 Expansion
- Power Ignition
- Compliant with EN50155 for Rail Transportation Applications

Powered by greensleeves ENERGY SOLUTIONS
Data Input / Output & Points List

- Bespoke configuration for project
- Modbus TCP/IP
- BACnet IP
- Reads/writes based on user input

<table>
<thead>
<tr>
<th>Points List</th>
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<tbody>
<tr>
<td>Outdoor air dry bulb temperature</td>
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<tr>
<td>Outdoor air wet bulb temperature</td>
</tr>
<tr>
<td>Building entering water temperature</td>
</tr>
<tr>
<td>Building leaving water temperature</td>
</tr>
<tr>
<td>Building water flow rate</td>
</tr>
<tr>
<td>Building fluid type</td>
</tr>
<tr>
<td>Building percentage by volume of second fluid</td>
</tr>
<tr>
<td>Building pump power</td>
</tr>
<tr>
<td>Ground Heat exchanger entering water temperature</td>
</tr>
<tr>
<td>Ground heat exchanger leaving water temperature</td>
</tr>
<tr>
<td>Ground heat exchanger water flowrate</td>
</tr>
<tr>
<td>Ground heat exchanger flow signal</td>
</tr>
<tr>
<td>Closed circuit cooling tower entering water temperature</td>
</tr>
<tr>
<td>Closed circuit cooling tower leaving water temperature</td>
</tr>
<tr>
<td>Closed Circuit cooling tower water flowrate</td>
</tr>
<tr>
<td>Closed circuit cooling tower power consumption</td>
</tr>
<tr>
<td>Closed circuit cooling tower pump power</td>
</tr>
<tr>
<td>Closed circuit cooling tower Set point</td>
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</tbody>
</table>
How it Works

- Build History
- Optimise
- Predict Future Performance
- Report Performance
History Builder & Reporting

- Understand how the Geothermal System is operating
- Generate custom reports for last week, month, or year
- Easily overlay data
- Export to .pdf or .csv file formats
- Easily view how your building load is performing compared with design data
History Report Builder
Prediction View

- Updates on a weekly basis
- Gives future set points and flow conditions
- Estimates future ancillaries operation
- Predicts building load based on design and actual data
Operational Optimization
Overview
How do we optimize?

- Integrated system modeling
- Particle Swarm Optimization (PSO)
- Alter set points & thresholds to,
  - Maximize heat pump performance
  - Minimize pumping costs
  - Optimize ancillaries
  - Manage the future loop conditions
What is the Integrated System Model?

- Mathematical model for physical system
- Each hydronic and power component is included
- Heat pump, ground heat exchanger, fluid cooler, boiler
- Used to estimate and predict temperatures, usage, and power consumption
Particle Swarm Optimization (PSO)

- Methodology for finding a global maximum / minimum for problem
- Iterative
- Sets of randomly generated “swarms” get tested
- Each generation “moves” towards global solution
Particle Swarm Optimization (PSO)
What do we optimize?

- Integrates with System Model
- Change set points within controls algorithm
- Get updated on regular basis
- Learn from past values to inform model
- Cooling Tower/Fluid Cooler Energy
- Pump Energy
- Building fluid temperature – enable heat pumps to operate at most efficient point
The GeoModule manages GHX temperature to increase efficiency.

Higher Temperature = Lower EER

Conventional GHX

GeoModule GHX

Example Project Outcome
Questions and Comments?

Want to know more....?
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Who is Greensleeves and what do we do?

- Greensleeves is a software company focusing on Ground Source Heat Pump (GSHP) systems
- Our roots are in the design, control and construction of geothermal HVAC
- Greensleeves provides real world software solutions for new-build construction as well as optimization / “rescue” of failing or failed GSHP systems and system monitoring
- Strong team of software engineers that also have HVAC backgrounds
- More than 2 million SF installed or under contract – USA and Australia
Greensleeve’s Capabilities

- Help Design and Optimize New Ground Heat Exchanger (GHX)
- Borefield Rescue
- Help Retrofit Existing GHX for Size Optimization
- Building Monitoring
- Determine the status of Existing Borefields
- Borefield Capacity Monitoring and Prediction of Failure
- Full Control of GHX and its Systems
Thank you!

The Greenleeves Team

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