GLHEPRO Inputs
Loads
Part 1

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Outline

- Why do we use loads?
- Load Representation
- Why don’t we use hourly loads directly?
- Types of loads (on heat pump, direct)
- Interaction of loads
- Theory and Verification
- Example(s)

Goals

- The main goals of this lecture are to introduce:
  - How heating and cooling loads are used in GLHEPRO.
  - How (and why) loads are represented in the “hybrid time step format”
  - The difference between loads on the heat pump and direct loads on the ground heat exchanger.
  - What types of loads should be input.
- This lecture is not intended to:
  - Teach users how to use EnergyPlus or similar tools.

Why do we use so many loads?

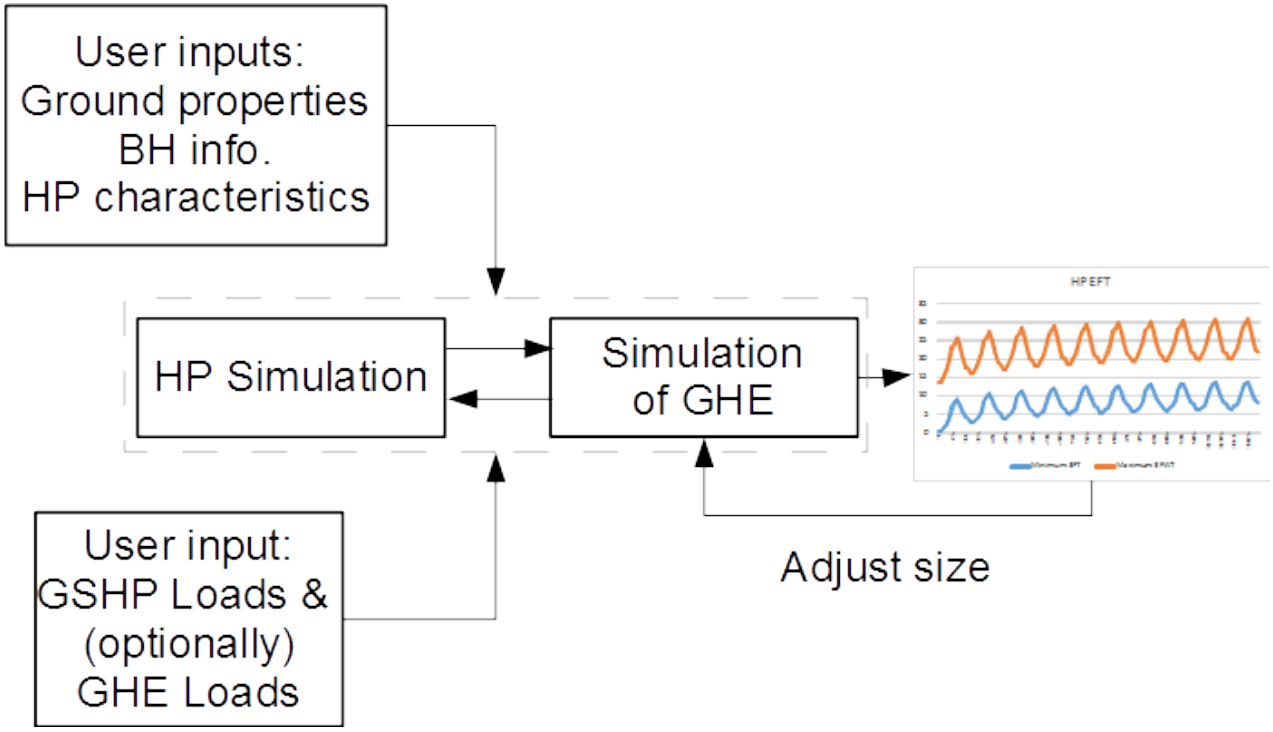
- Conventional equipment often sized with peak load from:
  - Single cooling design day.
  - Monthly cooling design days.
- The ground has a very long time constant, so the exiting fluid temperature from the ground depends on:
  - Current load
  - Loads in the past – recent and distant
  - Loads from more than a year ago important when loads are imbalanced and there is significant borehole interference.

Multi-year effects

- Long-term temperature build-up or draw-down.
- Controversial in some circles.
  - Some misinformation fed by limited experience.
- Based on physics of conduction heat transfer.
  - High groundwater velocities are rare, but can effect long-term heat buildup. See Chiasson, et al. (2000)
  - Percolation of rainwater unlikely to have significant effect.
- Anecdotal evidence for long-term temperature build-up.
- Not much high-quality field-data, though.

Load representation

- Why don't we use hourly loads?



Peak Load Analysis Tool

- Finds the peak heating day and peak cooling day of the year.
- Allows the user to test different peak load durations.
- Presents temperature rise (or fall) over the day in a normalized fashion for both:
  - Simulation of actual hourly load profile
  - Simulation of peak duration (rectangular) load profile.
- User finds the duration that most closely matches the temperature rise or fall

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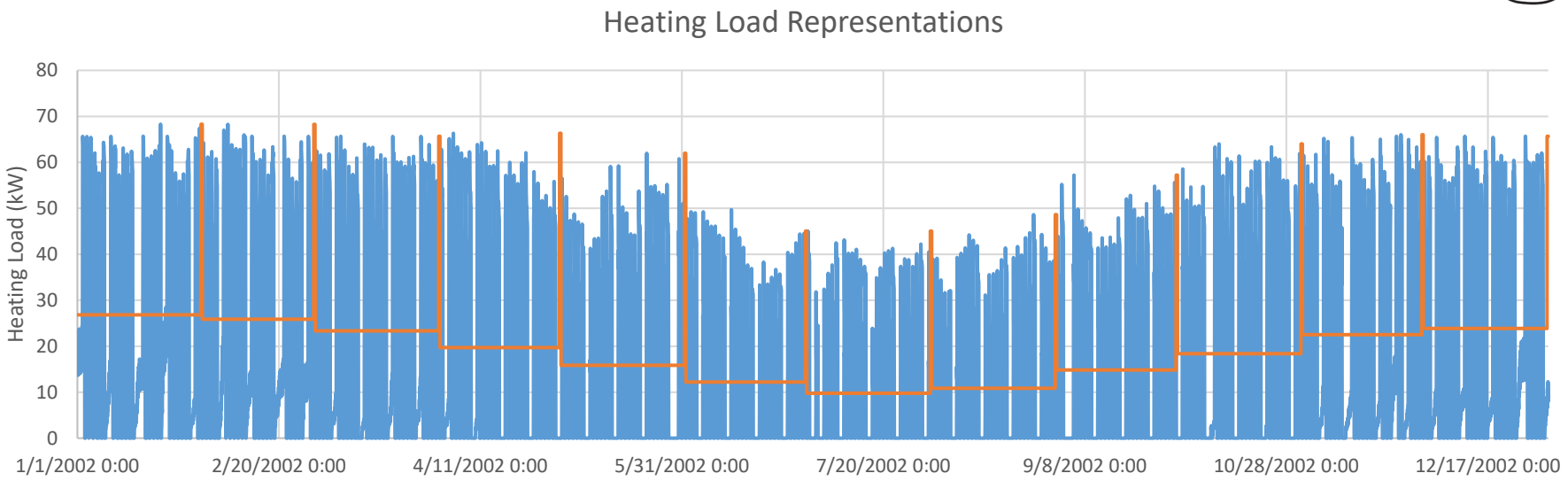
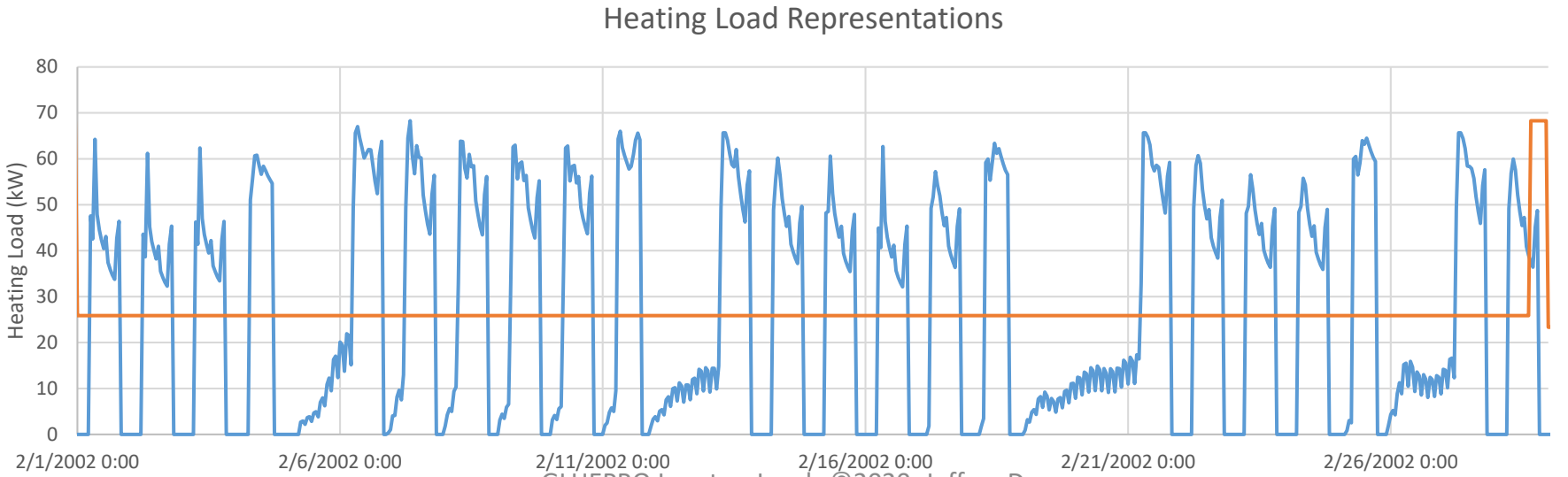




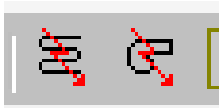
Solution: “Hybrid Time Step”

- Monthly heating/cooling loads +
  Monthly peak heating/cooling loads
- Duration of peak loads?
- Peak load analysis tool.
  - See Cullin and Spitler (2011) for theory.
  - Allows user to determine peak load duration that will give matching temperature response to actual hourly loads.
- Allows sizing to be done with relatively quick simulations.
- Sizing in seconds, not hours.

Block loads

- In the most common application (a traditional GSHP system with heating and cooling being provided by GSHPs).
  - We start with hourly loads for heat pumps serving all zones.
  - We add these together.
  - These are sometimes called “block loads”
- GLHEPRO 5.0 does not have a way to input loads on different heat pumps individually.

GSHP Loads vs. Direct Loads

- Two icons for two types of loads: 
- Direct loads () are used for loads that don't come through a heat pump. E.g.:
  - Using a fan coil unit for free cooling.
  - Preheating ventilation air by circulating ground loop fluid through a fin-tube heat exchanger.
  - A cooling tower used to reject excess heat. (But there is another approach for sizing this type of hybrid system.)
- For heat pump loads ():
  - Heat rejection is calculated based on clg. load and HP EFT
  - Heat extraction is based on htg. load and HP EFT
  - That is, compressor heat is added or subtracted.

Interaction of loads

- Effects of all monthly loads converted to a single monthly heat extraction/rejection rate.
- Peak heating loads (HP and direct) are assumed to occur simultaneously and must have the same duration.
- Peak cooling loads (HP and direct) are assumed to occur simultaneously and must have the same duration.
- Don’t paste the same loads in both places!

Variation between buildings

- Seems complicated – why do we need to compute the peak duration?
- Answer:
  - Buildings vary in the degree to which the design is dominated by:
    - Monthly loads (More important if annual load is imbalanced)
    - Peak loads (More important if building has short, sharp peak loads.)
  - See Young (2004) for examples of a small office building and an “idealized” church building.

Warning

- An artificial dominance due to peak loads can be created by:
  - In the simulation, turning on all of the heat pumps at the same time, after night and weekend setback.
  - In real life, by doing that.
    (Though this is fixable by distributing the start time.)

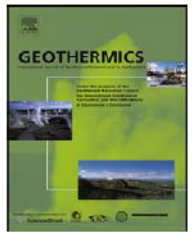
Theory

Geothermics 40 (2011) 144–156

Contents lists available at ScienceDirect

Geothermics

journal homepage: www.elsevier.com/locate/geothermics



A computationally efficient hybrid time step methodology for simulation of ground heat exchangers

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Cullin and Spitler (2011)

- Gives the theory for this approximation.
- Compares the sizes determined with:
  - An hourly simulation
  - A hybrid time step simulation

  For three buildings in 16 locations.
- The hybrid time step approach gives oversizing between +7.8% and -5.7%.
- Causes:
  - Single peak htg. duration and single peak clg. duration.
  - Peaks assumed to occur at the end of the month.
  - Sometimes day before peak day has an effect.

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Part 3 – Example 1

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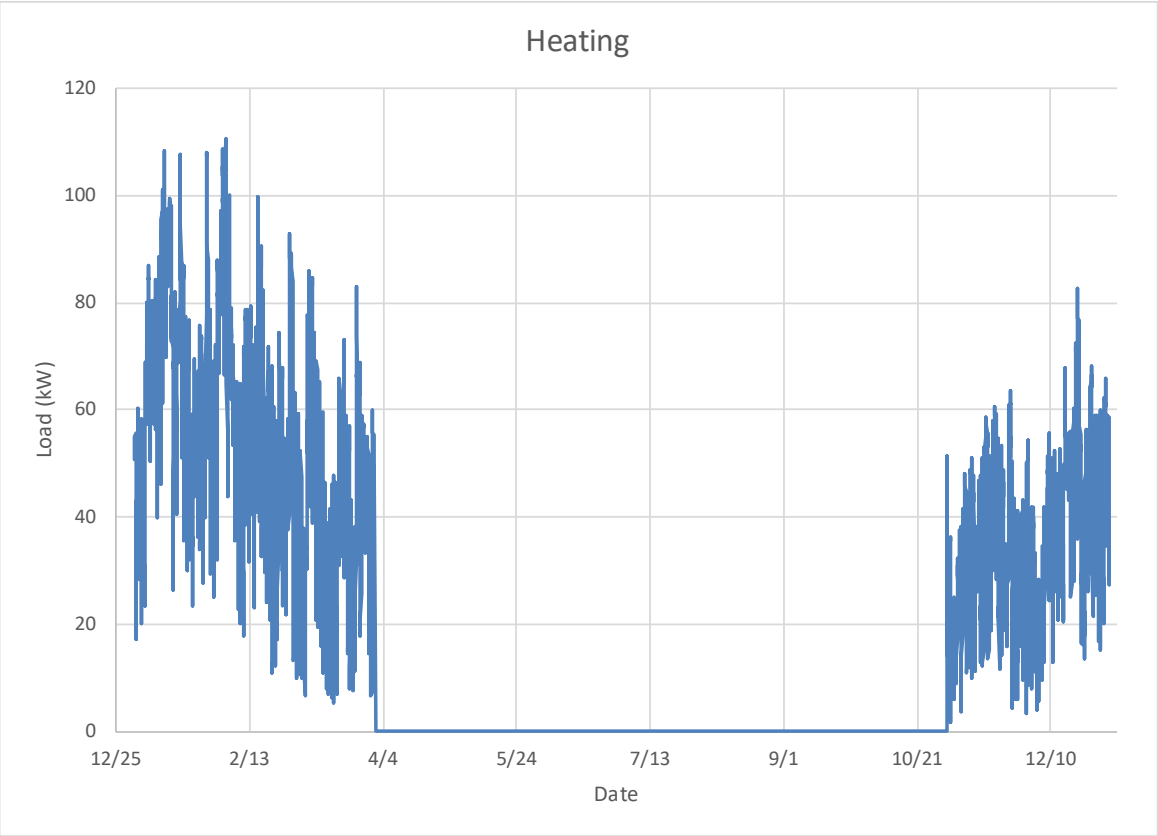
Example 1

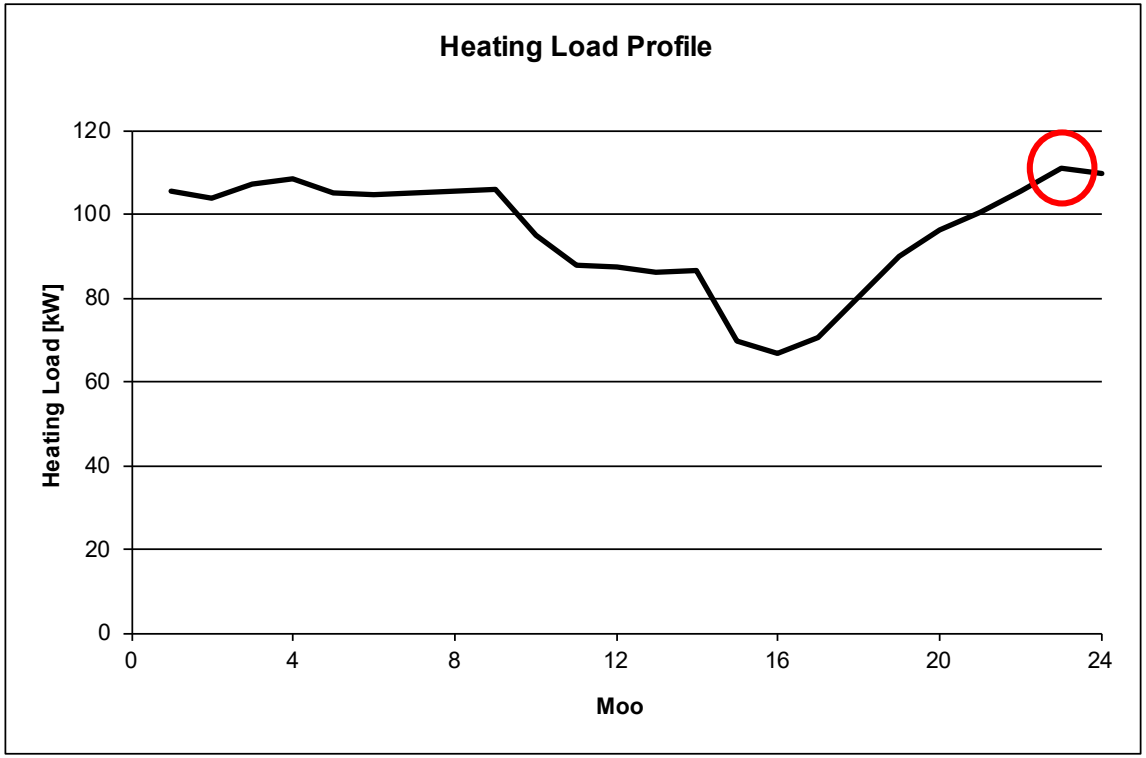
- An existing state park “lodge” (i.e. a small hotel) is considering replacing existing system with a GSHP system.
- A rough energy model was developed in EnergyPlus.
- It was then modified to give the monthly utility bills correctly.
- Hourly loads were determined from the revised model.

Peak Heating

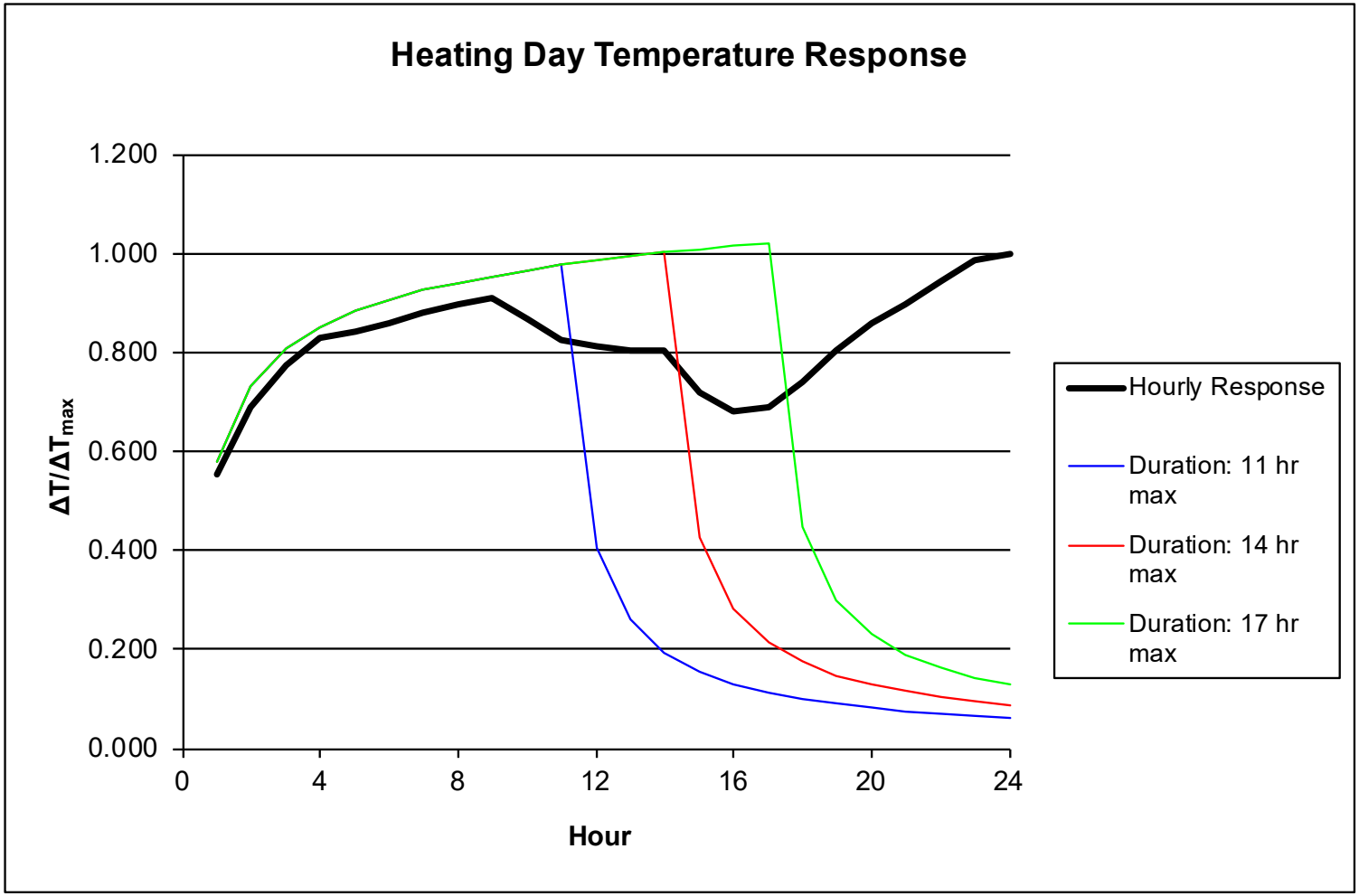
- Peak heating load occurs on February 3, 10-11 p.m.



Peak heating day

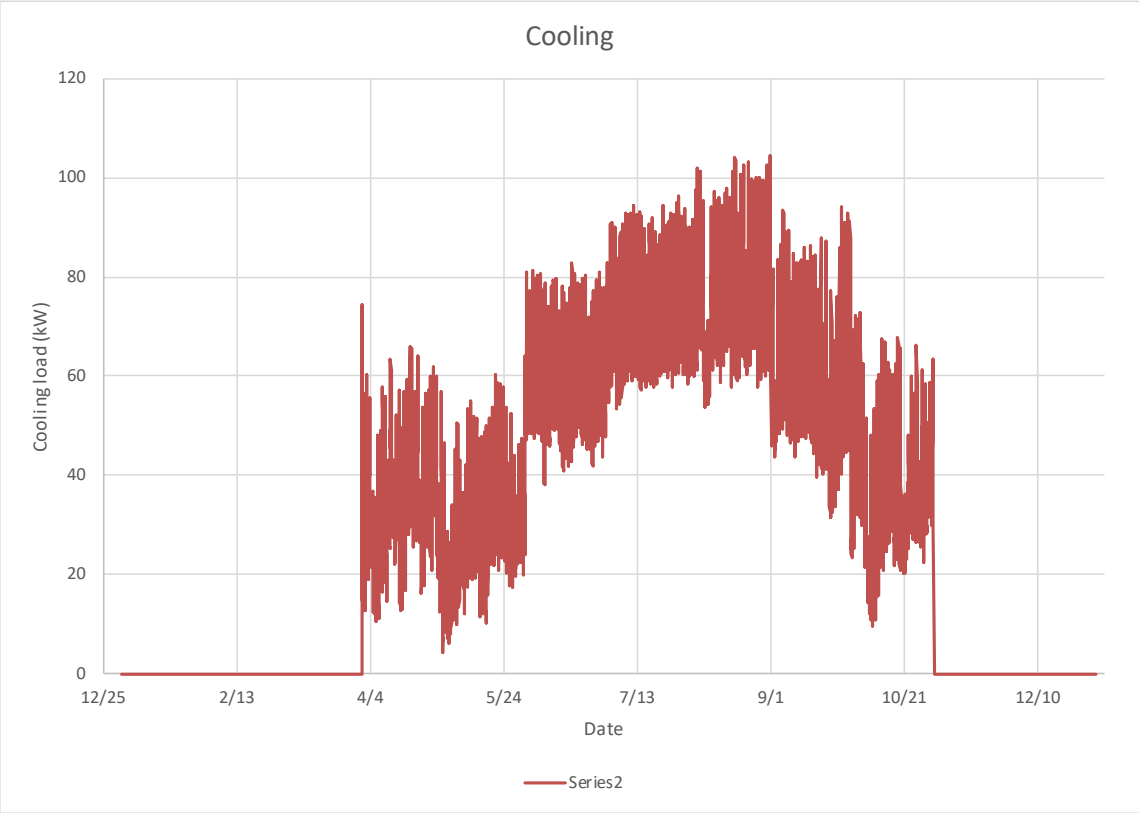


Matching peak htg. day response

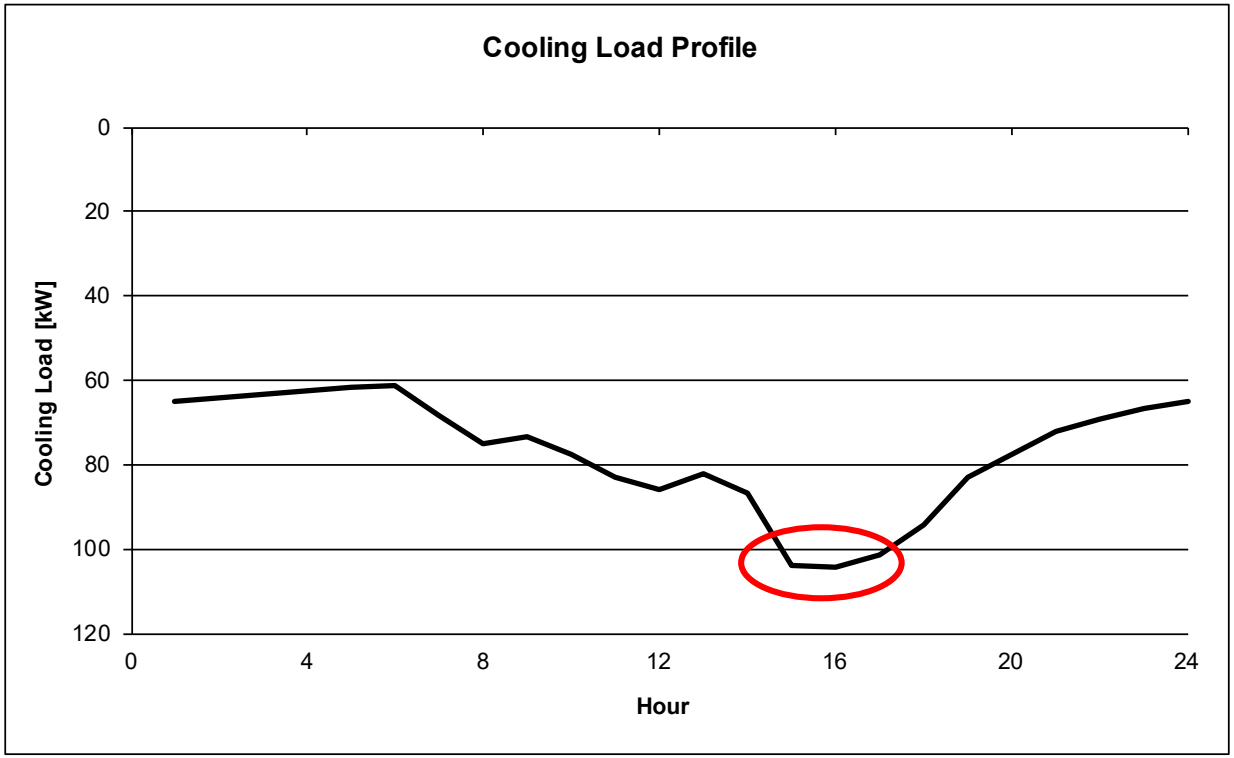


Peak cooling

- Peak cooling load occurs on August 31, 3-4 p.m.

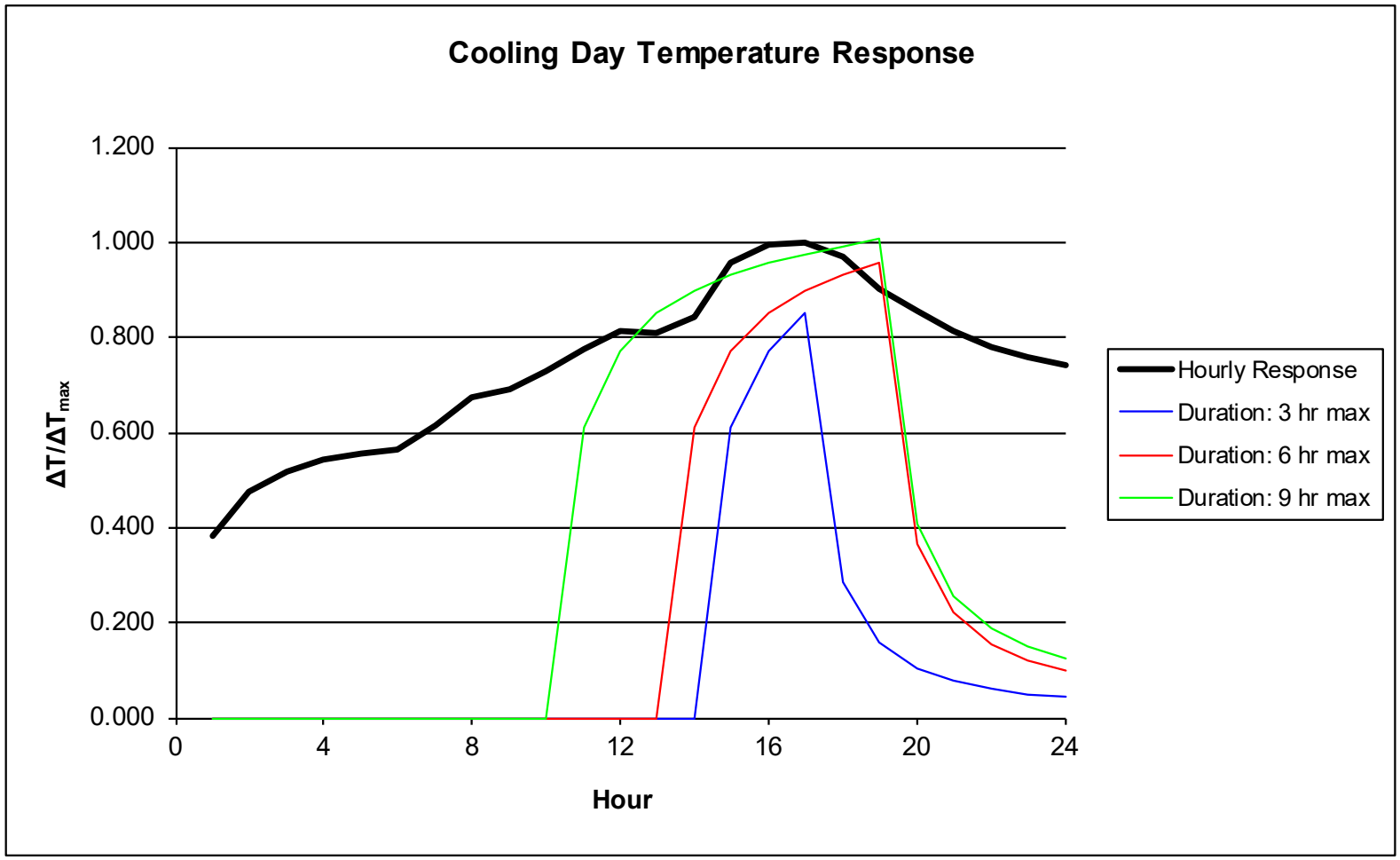


Peak cooling day

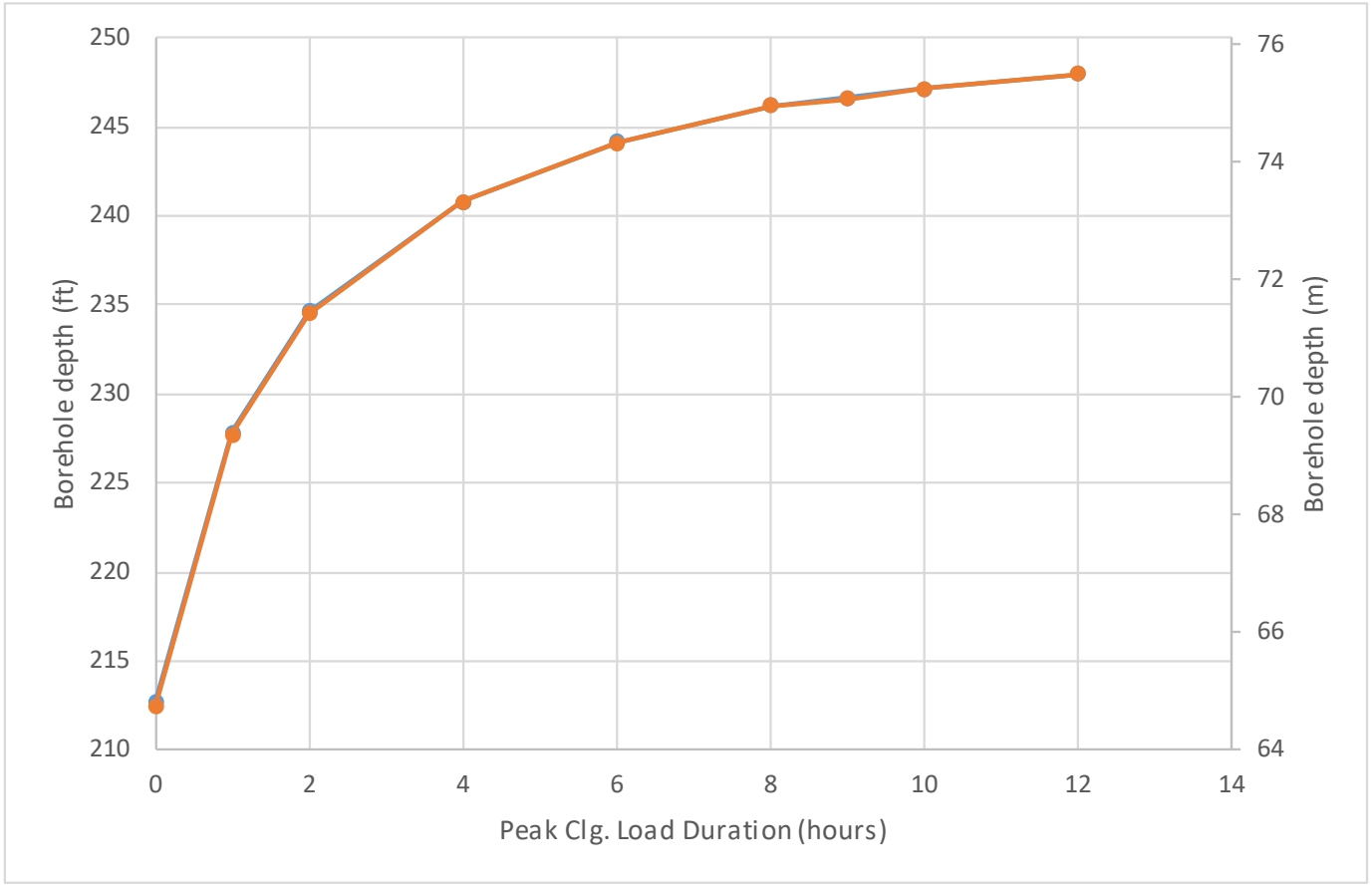


Note: plotting convention for cooling loads based on cooling loads being negative.

Matching peak clg. load response



Sensitivity of size to duration



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Part 4 – Example 1
Live Demo

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Live Demo here

GLHEPRO Inputs
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Part 5 – Example 2

(Placeholder for an example with both heat pump loads and direct loads)

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References

- Software
  - GLHEPRO: https://hvac.okstate.edu/glhepro/overview
  - EnergyPlus: https://energyplus.net/
- References

  - Chiasson, A. D., S. J. Rees and J. D. Spitler. 2000. *A Preliminary Assessment of the Effects of Ground-Water Flow on Closed-Loop Ground-Source Heat Pump Systems*. ASHRAE Transactions 106(1): 380-393.*
  - Cullin, J. R. and J. D. Spitler. 2011. *A computationally efficient hybrid time step methodology for simulation of ground heat exchangers*. Geothermics 40(2): 144-156.
  - Young, T. R. 2004. *Development, Verification, and Design Analysis of the Borehole Fluid Thermal Mass Model for Approximating Short Term Borehole Thermal Response*. MS, Oklahoma State University.*

* available at https://hvac.okstate.edu