Effects of Imbalanced Loads on Long-Term Entering Water Temperatures in Closed Loop Ground Source Heat Exchange Systems

Jonathan Sanger
John R. Kastrinos, P.G.
E. Quinn Lewis, P.E.
Katherine A. LaBella, P.E., C.G.D.

HALEY ALDRICH

Agenda

1 Ground-Source Heat Exchange and Electrification

2 Target Entering Water Temperatures for Long-Term System Operation

3 Modeling – Varying Load Profiles and Thermal Properties

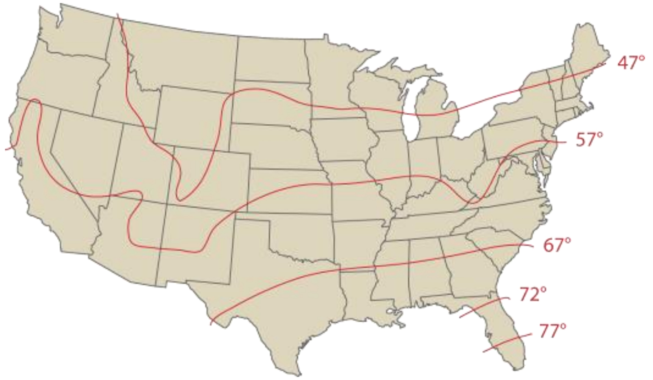
4 Summary

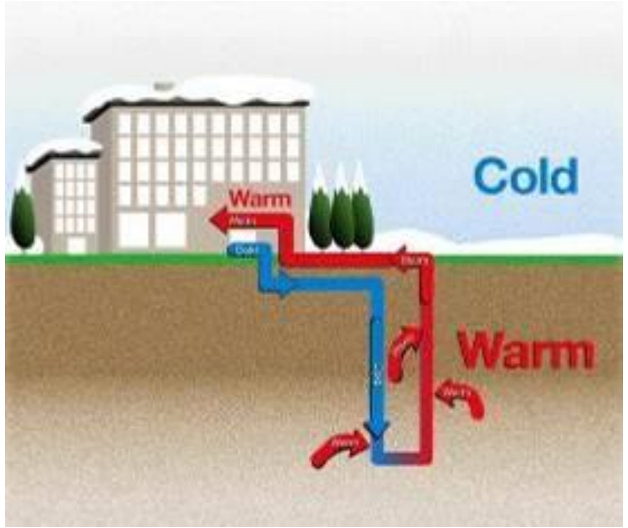
5 Questions

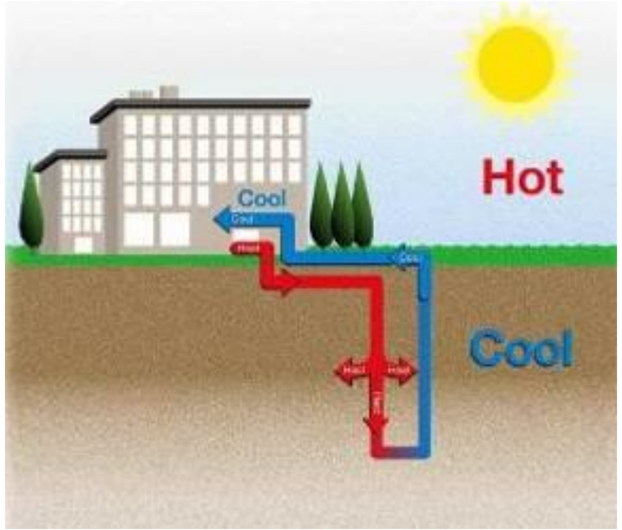
Ground Source Heat Exchange (GSHE) and Electrification

Ground-Source Heat Exchange (Geothermal)

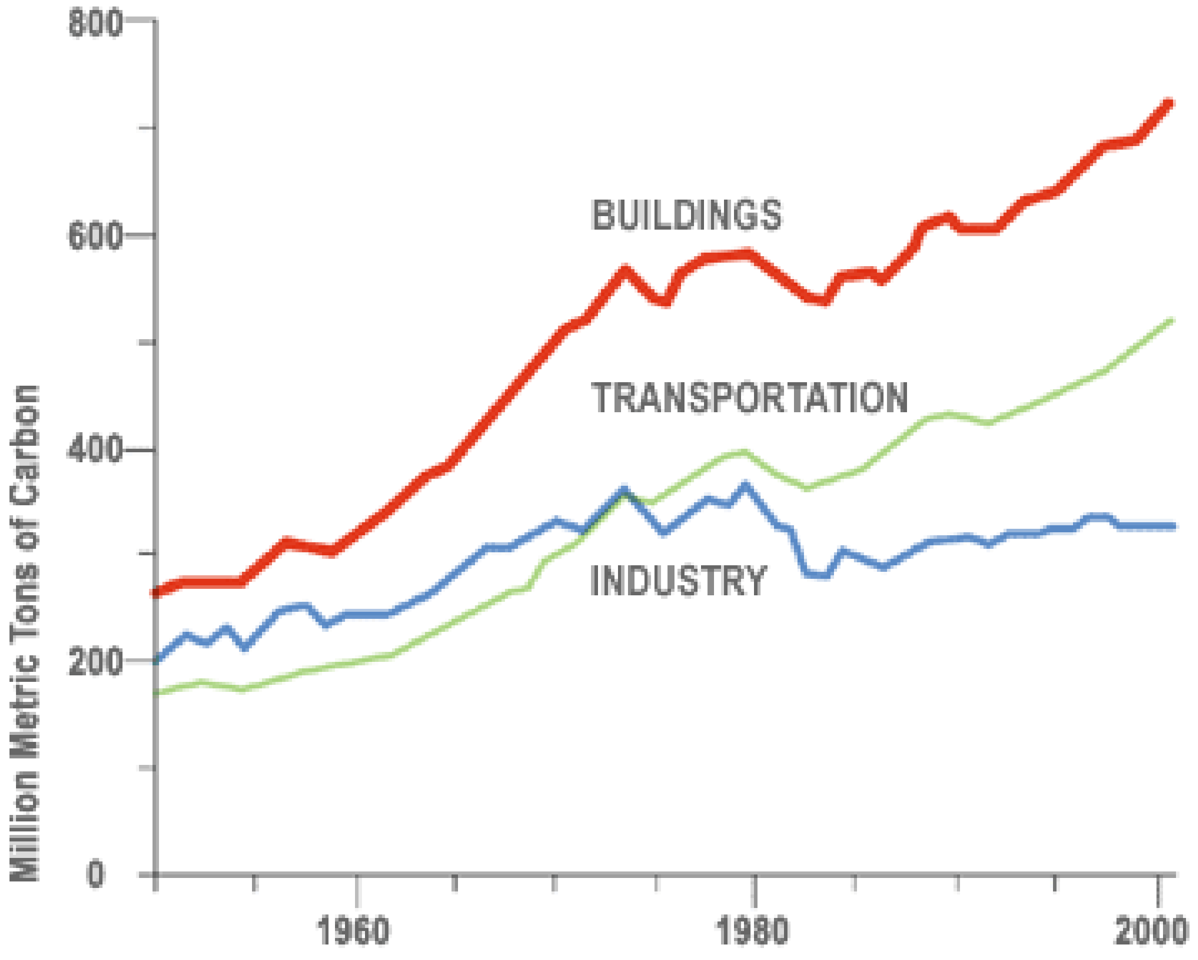
- Stable subsurface temperatures
  (Northeast 50-55^{o}F)
- Draw heat from the ground in the winter
- Reject heat to the ground in the summer







Buildings Contributions to Carbon Emissions

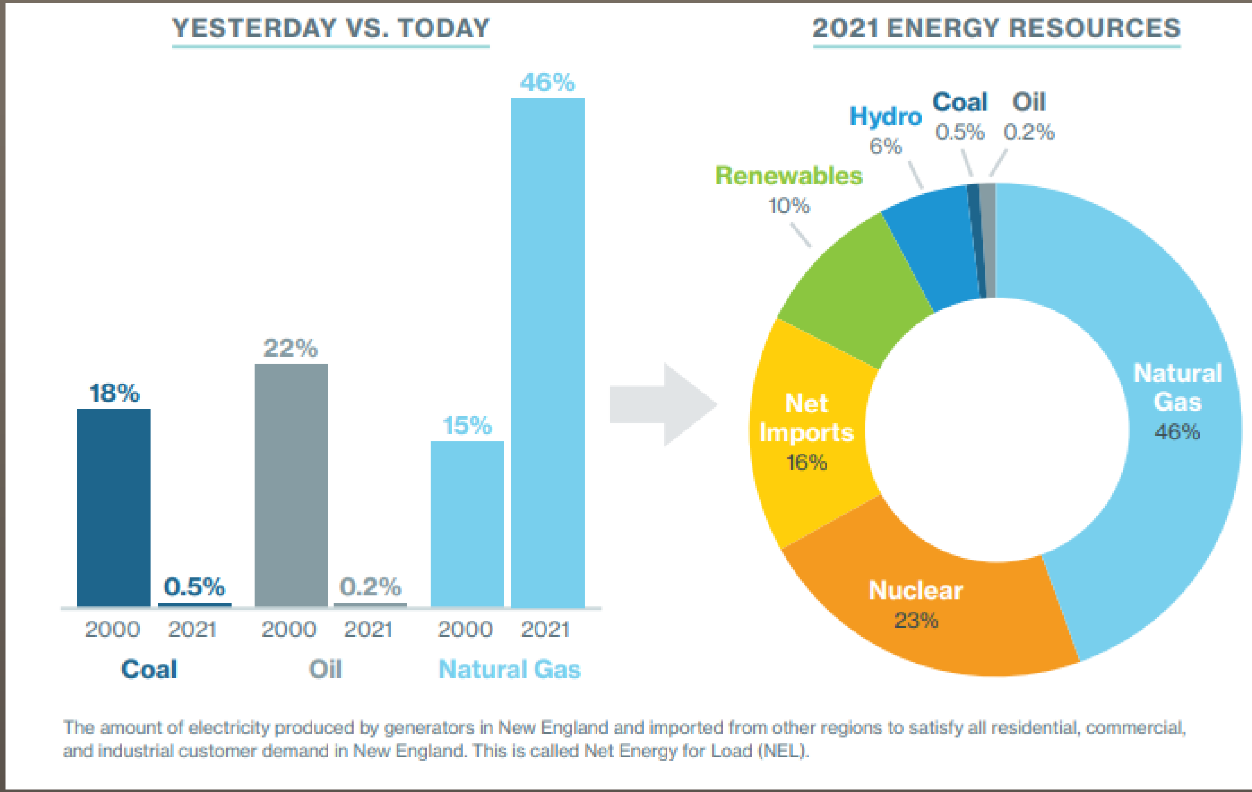


Source: Department of Energy

Energy in New England – Shifting from Fossil Fuels

- Stable earth temperatures make GSHE efficient year-round for heating and cooling
- Electrification - GSHE replaces local fossil-fuel heating sources using electricity from a "green" grid (declining use of oil and coal)

Grid vs. Residential & Commercial Usage

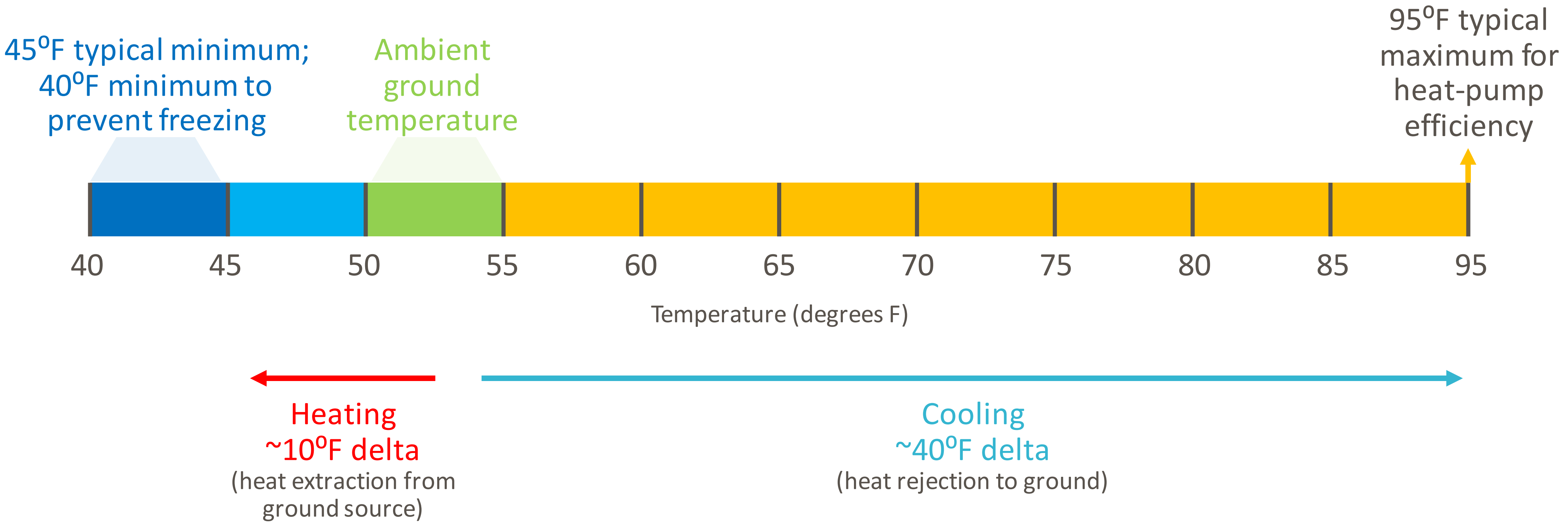


Source: www.iso-ne.com

HALEY ALDRICH

Target Entering Water Temperatures for Long-Term System Operation

Target Entering Water Temperatures (EWTs)



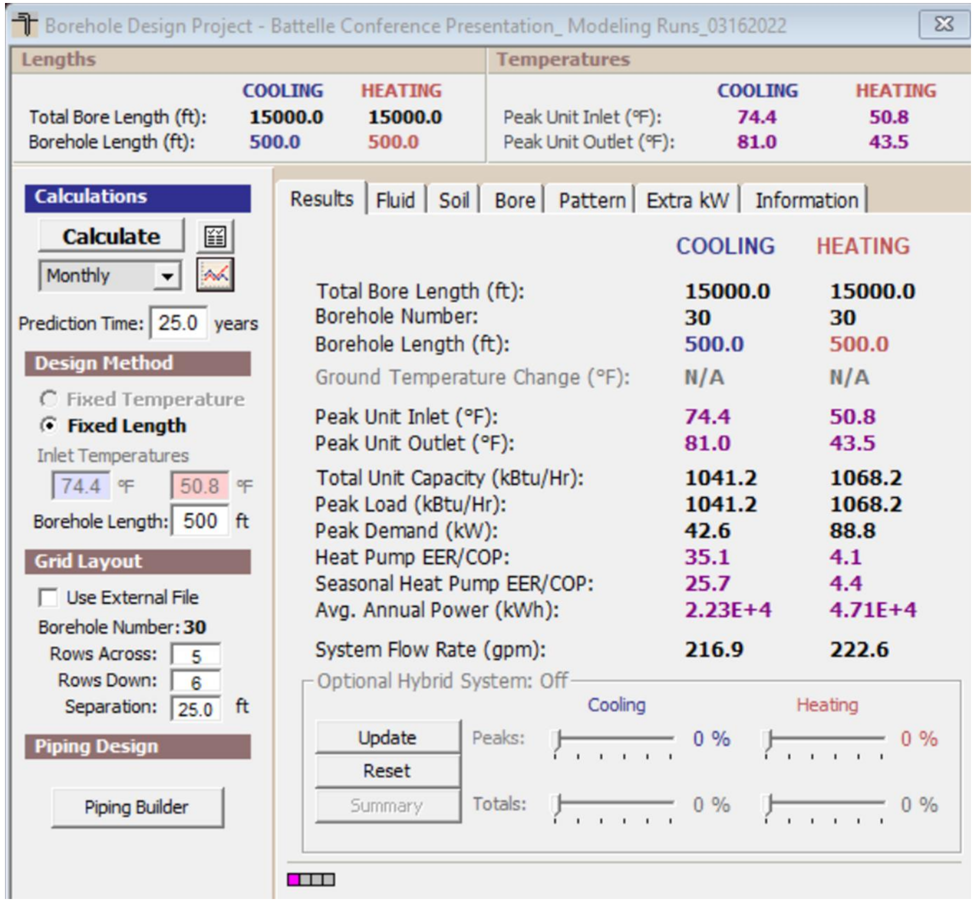
Inherent imbalance toward cooling due to higher allowable delta in EWTs; temperature range must be maintained over long-term operating conditions.

Modeling – Varying Load Profiles and Thermal Properties

HALEY ALDRICH

Bore-field modeling

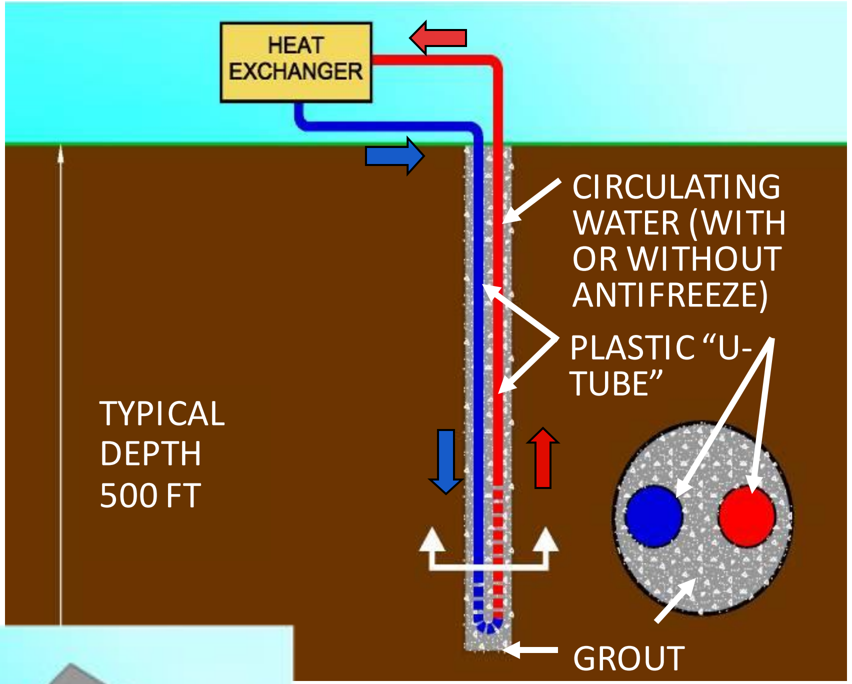
- Input parameters
  - Loads (monthly or hourly)
  - Formation thermal conductivity
  - Loop thermal properties (borehole resistance)
  - Circulating fluids (water or water/glycol mix
  - Bore-field configuration/layout
  - Target EWT temperature range

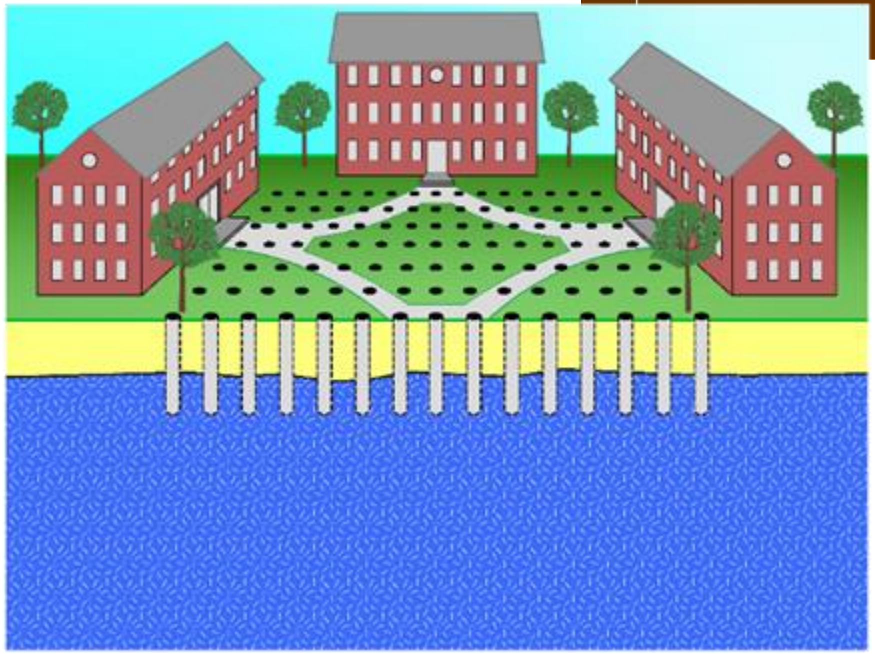


Source: Ground-Loop Design (GLD) software

Bore-field modeling, cont'd

- Design objectives:
  - # of boreholes
  - Borehole spacing
  - Borehole depth/total exchanger length
  - Exchanger type i.e., single U-loop, double U-loop (Quad loop), concentric





Contrasting load profiles*

Month	Monthly Cooling (kBtu/mo)	Monthly Heating (kBtu/mo)
January	12,400	154,774
February	11,339	132,663
March	22,099	68,241
April	25,947	32,545
May	45,437	37,766
June	82,813	25,150
July	77,016	9,065
August	99,950	16,904
September	123,378	17,627
October	34,073	45,532
November	25,002	60,906
December	14,571	108,155
Total	**574,024**	**709,327**
Peak Maximum (kBTU)	**1,041**	**1,068**
Peak Maximum (tons)	**87**	**89**

Balanced

$$\frac{annual\ cooling}{annual\ heating} = \frac{574{,}024}{709{,}327} = 0.81$$

Month	Monthly Cooling (kBtu/mo)	Monthly Heating (kBtu/mo)
January	37,199	154,774
February	34,016	132,663
March	66,243	68,241
April	75,211	32,545
May	134,134	37,766
June	238,662	25,150
July	230,662	9,065
August	293,522	16,904
September	312,292	17,627
October	98,900	45,532
November	74,273	60,906
December	42,282	108,155
Total	**1,637,396**	**709,327**
Peak Maximum (kBTU)	**1,500**	**1,068**
Peak Maximum (tons)	**125**	**89**

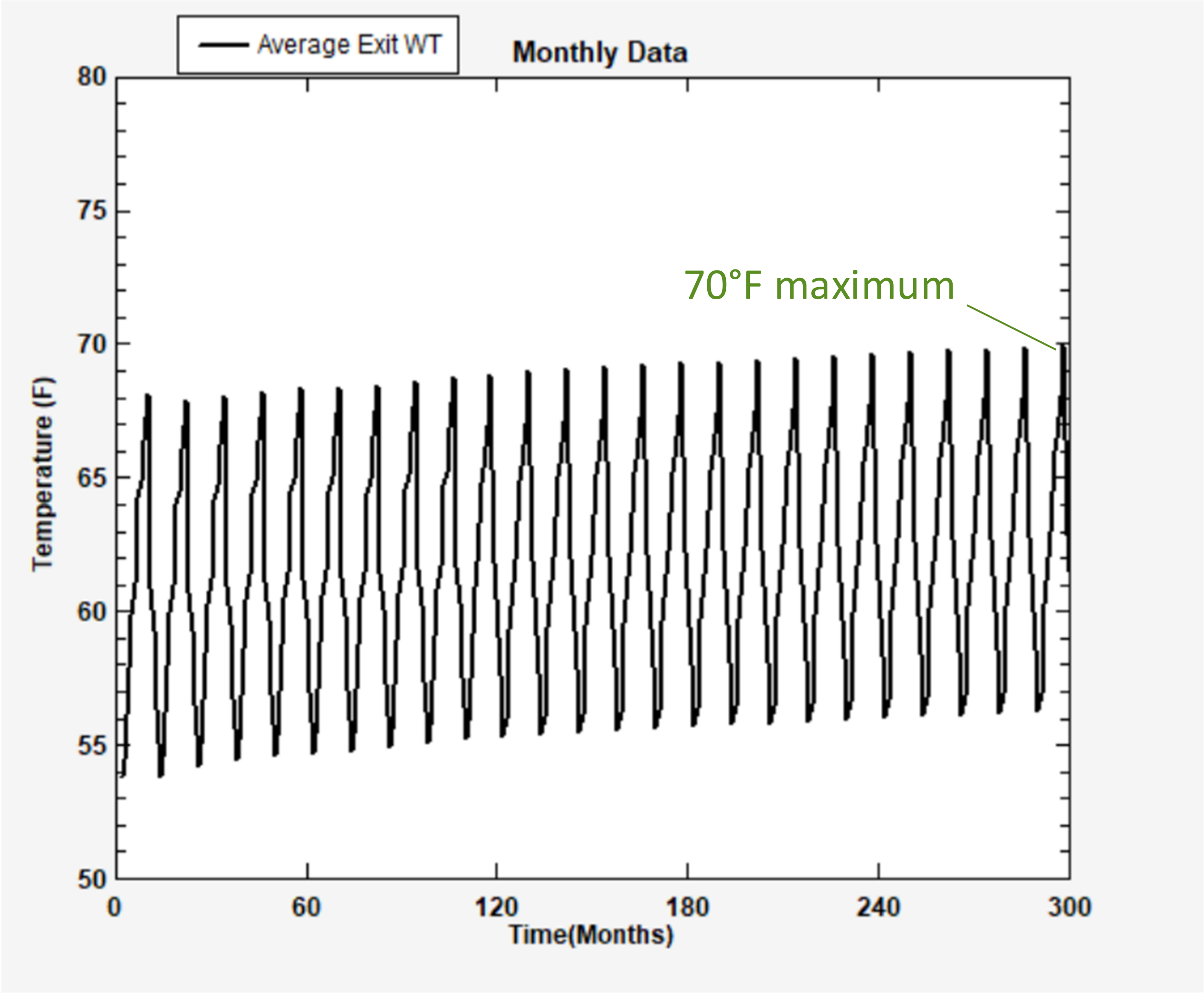
Imbalanced

$$\frac{annual\ cooling}{annual\ heating} = \frac{1{,}637{,}396}{709{,}327} = 2.3$$

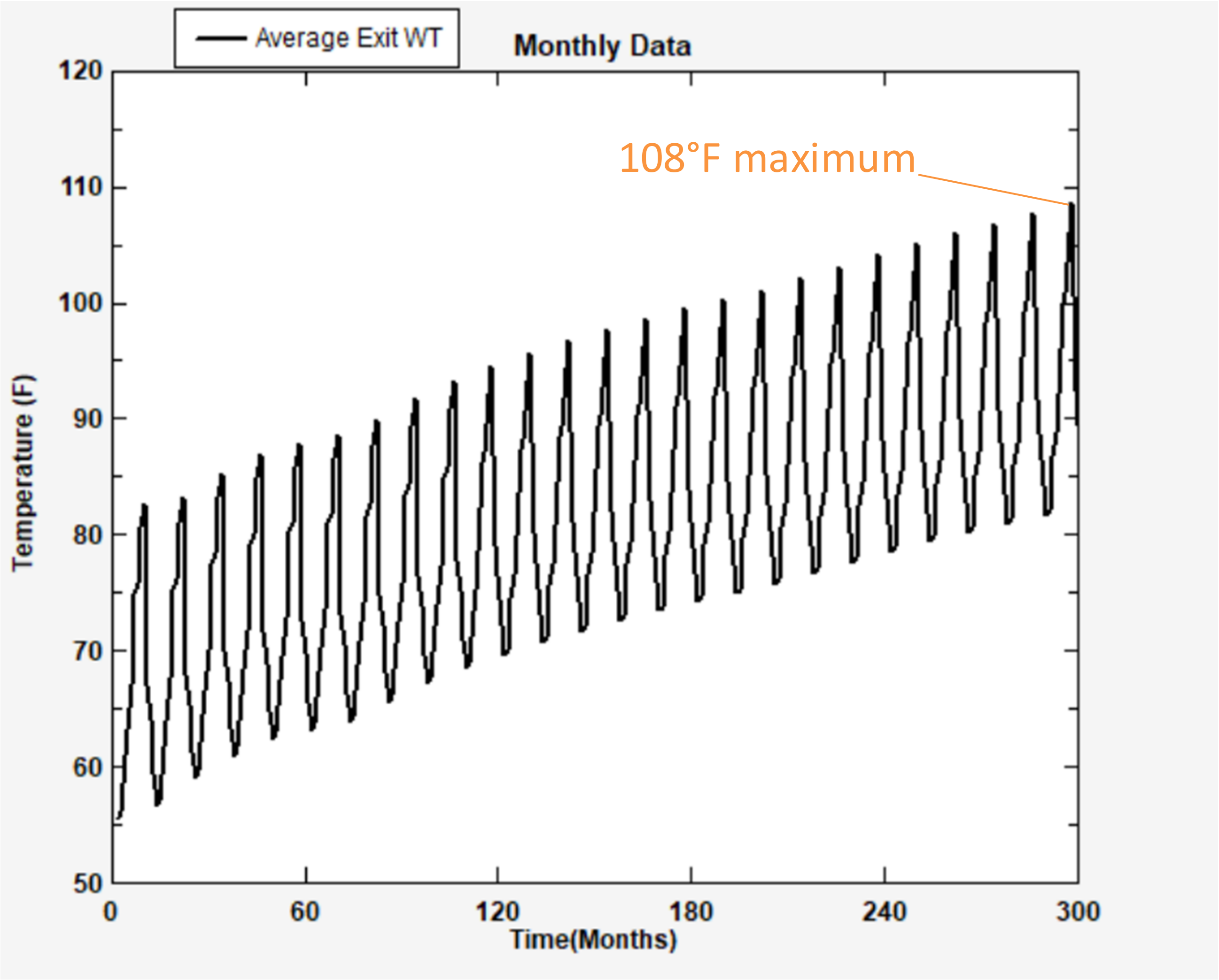
**Typical Commercial/Institutional Buildings*

HALEY ALDRICH

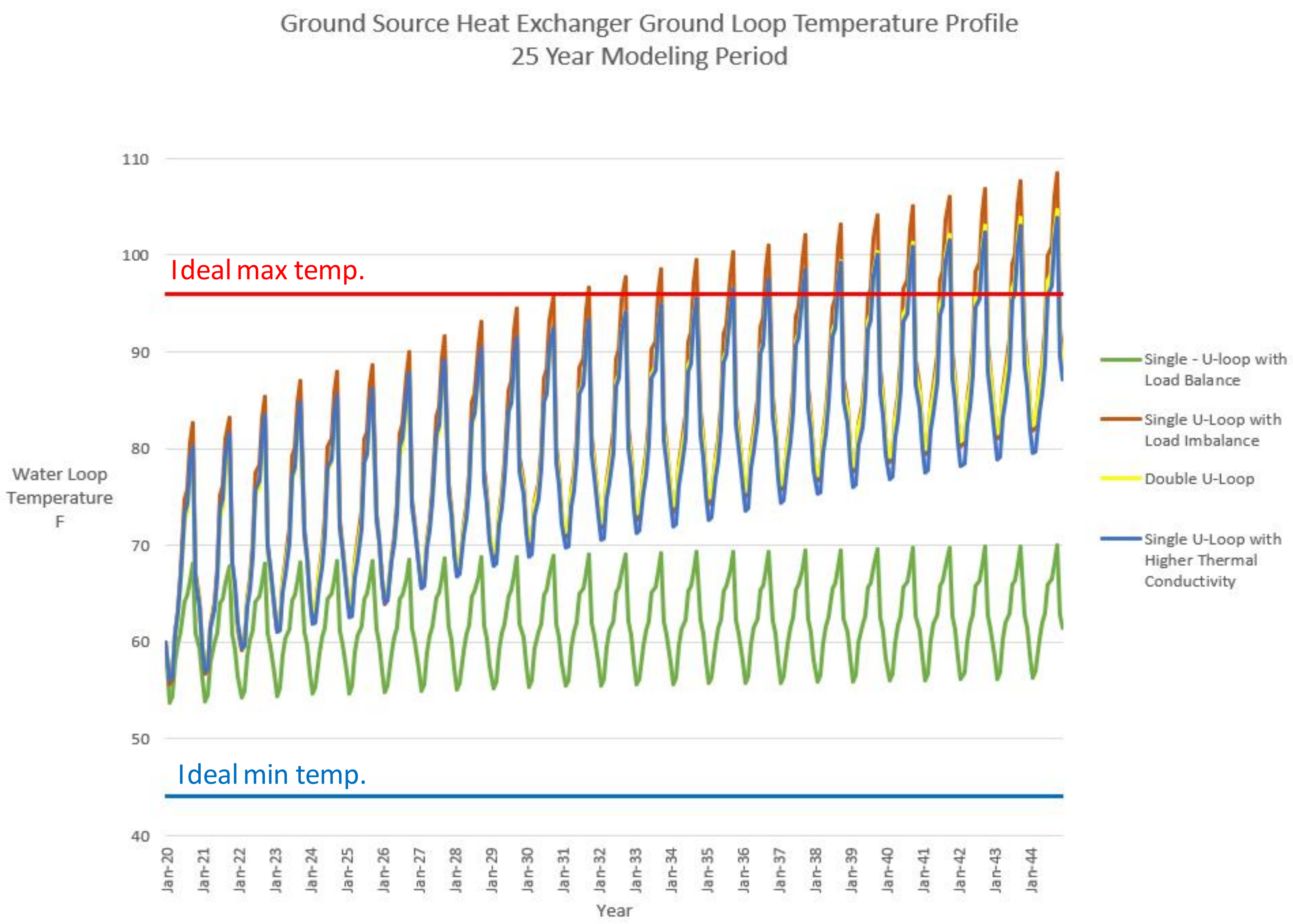
Load profile 1 (balanced): 25-year projection of exiting water temperatures



Load profile 2 (imbalanced): 25-year projection of exiting water temperatures



Effects of varying input parameters – loop design (double U-loop vs. single U-loop), increased ground thermal conductivity



Summary

- Balanced heating and cooling loads are key to maintaining an acceptable range of EWTs for efficient long-term heat pump operation.
- Target ratio for **cooling:heating** typically is around 0.8 to 0.9 for balanced annual ground exchange loads.
- More favorable thermal properties and double U-loops improve EWTs over time, but typically will not compensate for imbalanced loads.

HALEY ALDRICH

Questions?

Jonathan Sanger
Environmental Specialist

- Jsanger@haleyaldrich.com
- (585) 321.4230
- Haley & Aldrich Inc.

HALEY ALDRICH