INNOVIA GEO

Decarbonizing Heating and Cooling
From the Ground Up

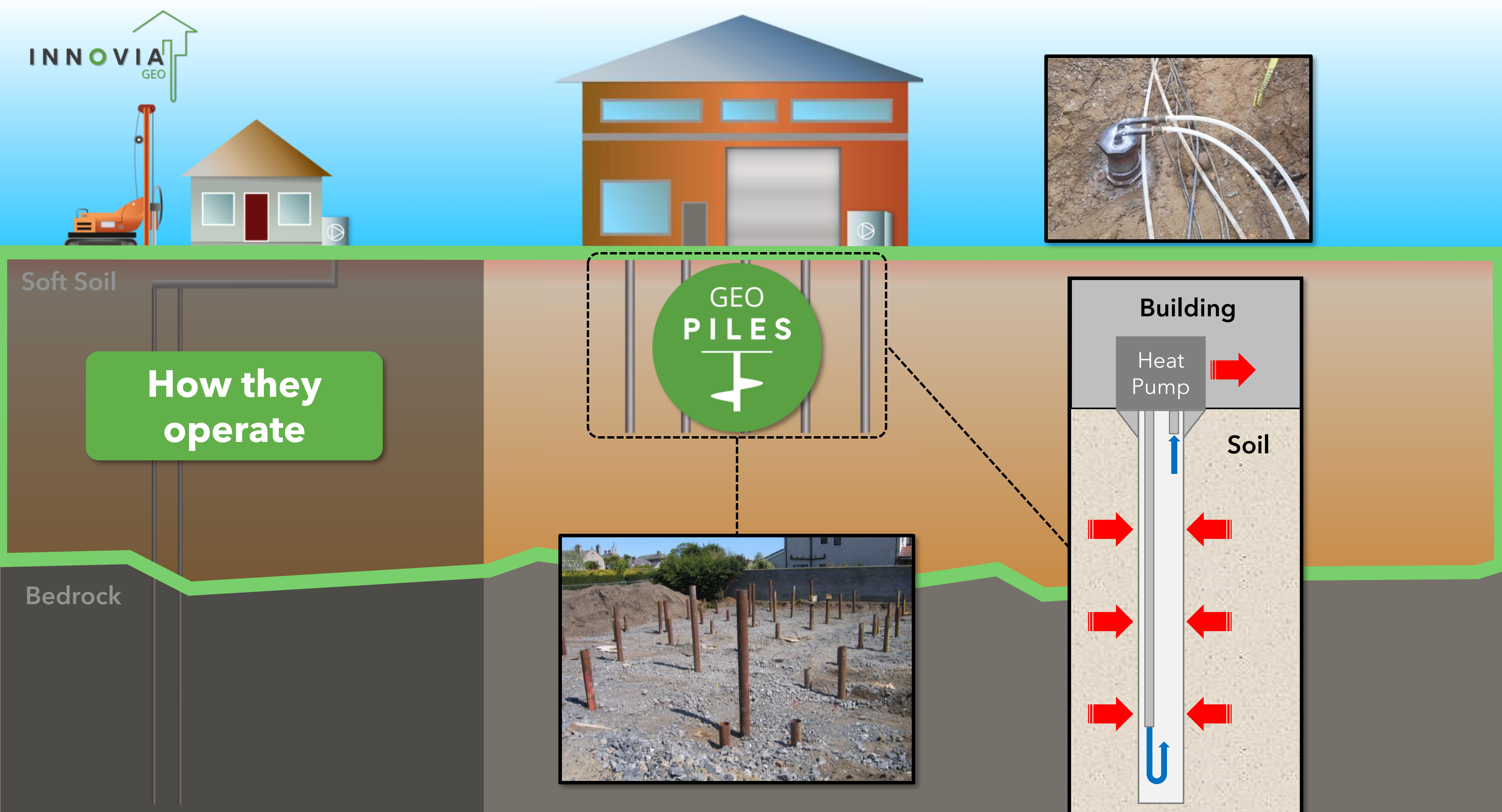
Overview of project and objectives

Project Description:

Demonstrate a geo-exchange system integrated into helical steel piles to provide efficient geothermal space heating and cooling to a building in SW Ontario.

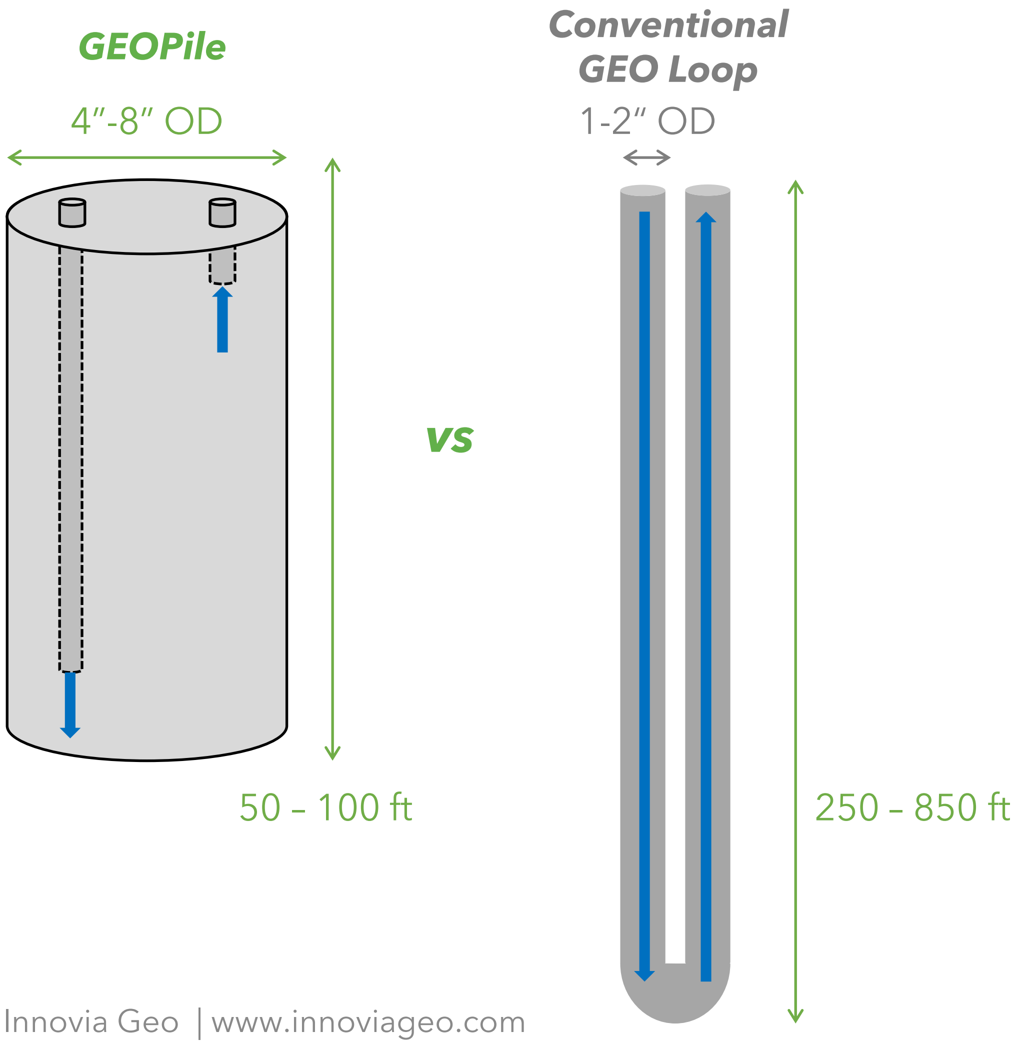
Objectives:

1. Demonstrate operational viability of full-scale system
2. Compare performance versus conventional vertical closed loop geothermal systems
3. Evaluate energy and emissions reduction potential versus alternative HVAC systems


INNOVIA
GEO
Soft Soil
How they operate
Bedrock
GEO
PILES
Building
Heat Pump
Soil

Comparison vs conventional ground loops

New paradigm for GEO: low-flow and high-volume system



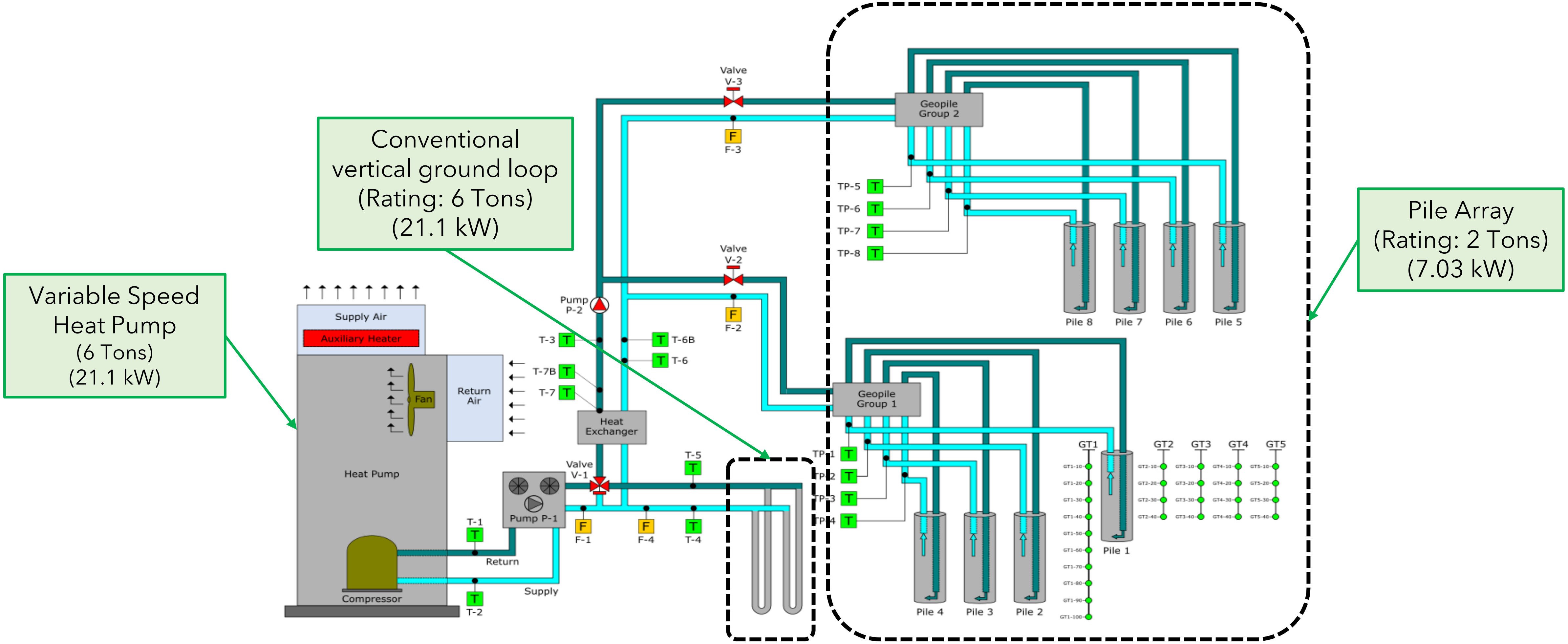
Time spent in ground

Conventional GEO Loop	***~8 minutes***
GEOPile	***>2 hours***

Project Location: Eby Rush TS

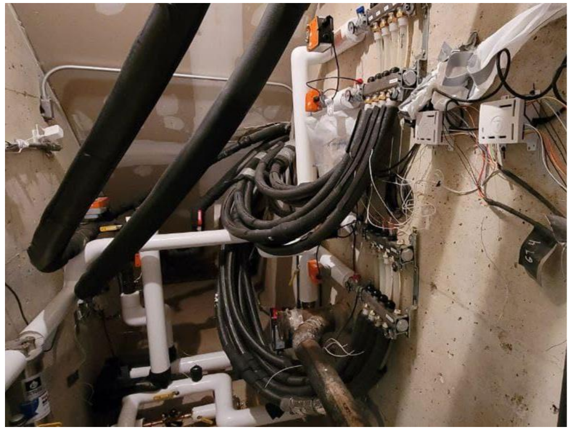
Location:	Waterloo, Ontario, Canada
Host:	Enova Power

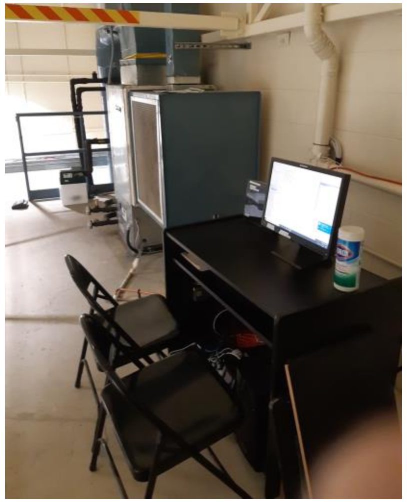
Eby Rush System Schematic



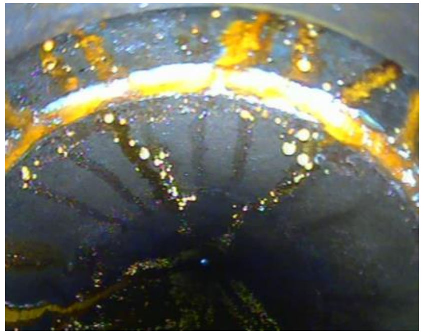
Eby Rush System Installation

Mechanical system and control system





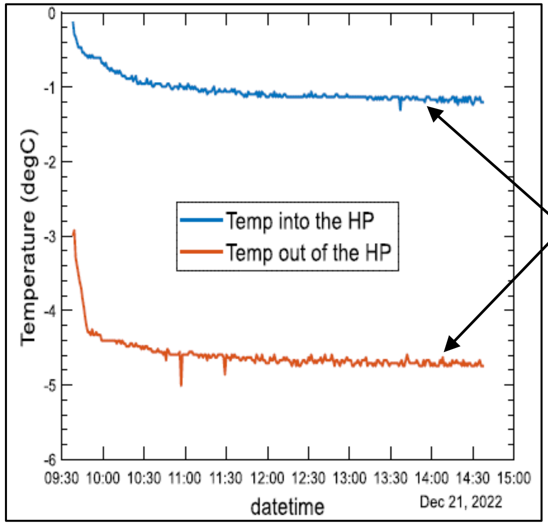
Challenge experienced during installation

Problem: *Leaking found at three pile section couplings during installation*	  
Immediate Solutions:	1. Cured-in-place pipe patches 2. Heat exchanger to separate fluid loops  
Long-Term Solutions Evaluated:	1. QC processes to test joints 2. Interior plastic pipe grouted inside of steel pile

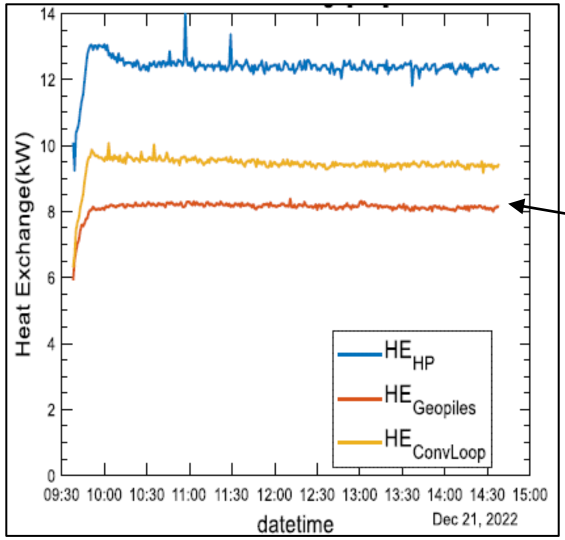
Results

Objective 1: Demonstrate operational viability of system

1. Functional tests completed from summer 2021 to summer 2023
2. System operated in both heating and cooling within industry standard operating temperature ranges for closed-loop geothermal systems
3. Steady state rating of ~2 Tons for the pile array was validated



Inlet and outlet temperatures at the heat pump are stable at a constant load.



Steady state capacity of the pile array was 8 kW (~ 2 Tons) during this time.

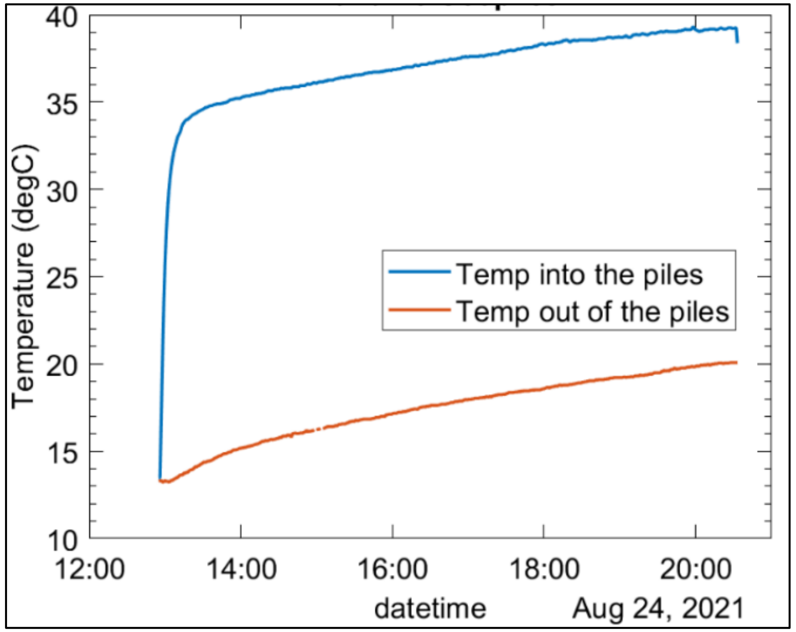
Results

Objective 2: Comparison vs. Conventional Ground Loop

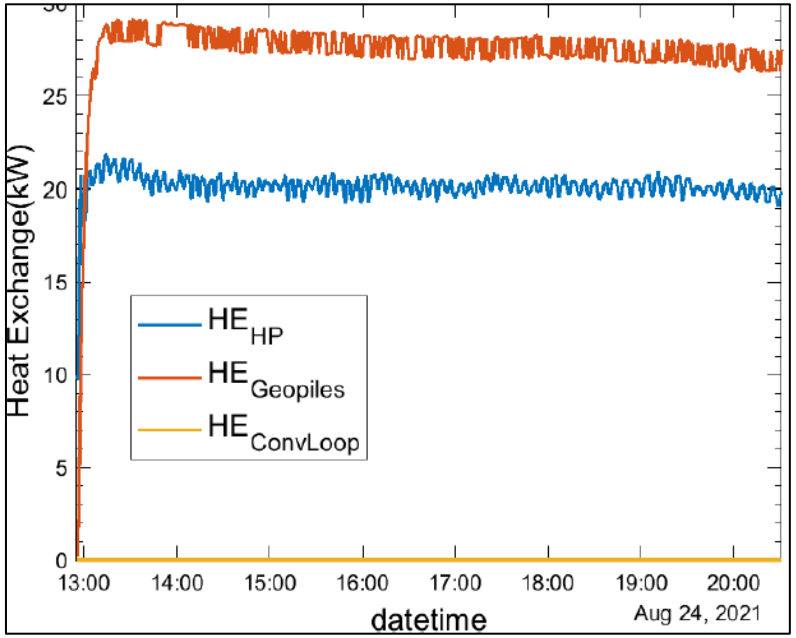
1. Pile Array required substantially less energy for pumping
   - <20% pumping power versus the ground loop (scaling up to 6-Tons)
2. Pile Array was able to provide better supply temperatures during many comparative tests
3. Large fluid volume of Pile Array provided unique thermal properties:
   1. GEOPiles could be "overloaded" above steady-state rating for periods of time
   2. GEOPiles could "recharge" when system was off or below steady-state rating
4. Opportunities for active control strategies to optimize based on:
   1. System efficiency
   2. Electricity prices
   3. Emissions

Example: "Overload" Property

1. Pile Array was able to operate significantly above the 2 Ton steady-state rating for significant (multi-hour) periods of time
2. Potential to utilize as a "peaking" capacity

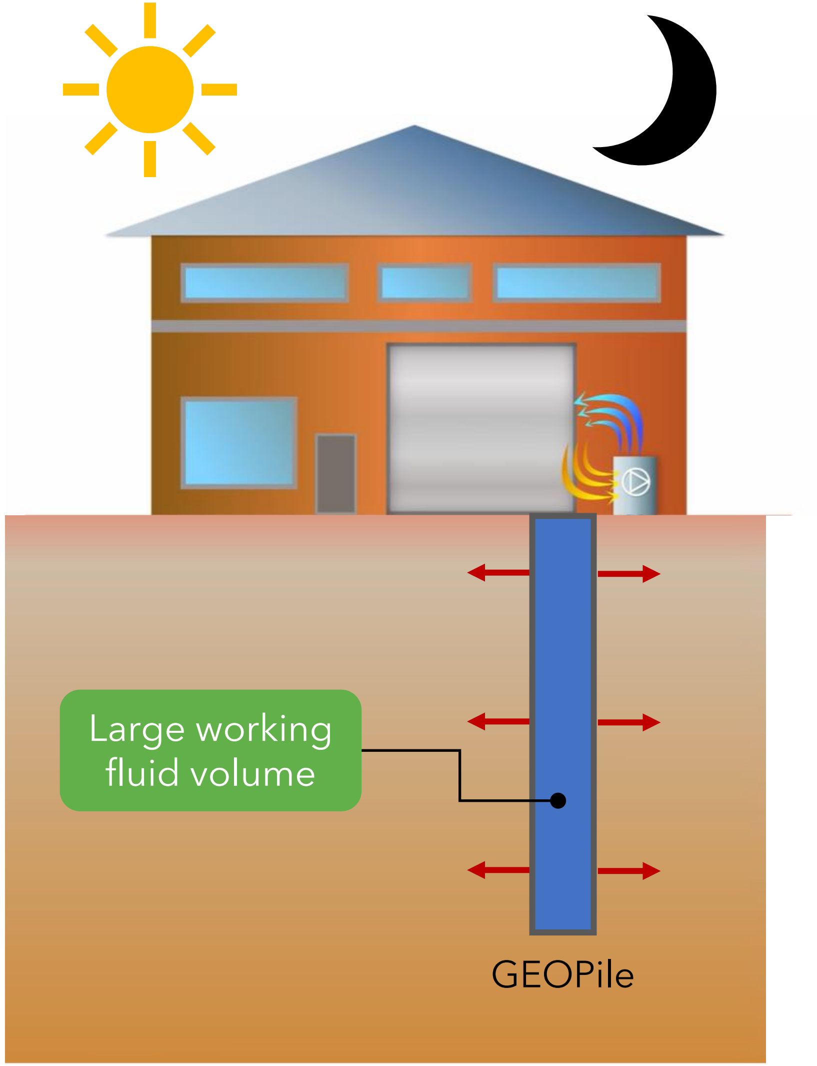


Large fluid volume enables a large ΔT with a slow increase in operating temperature.

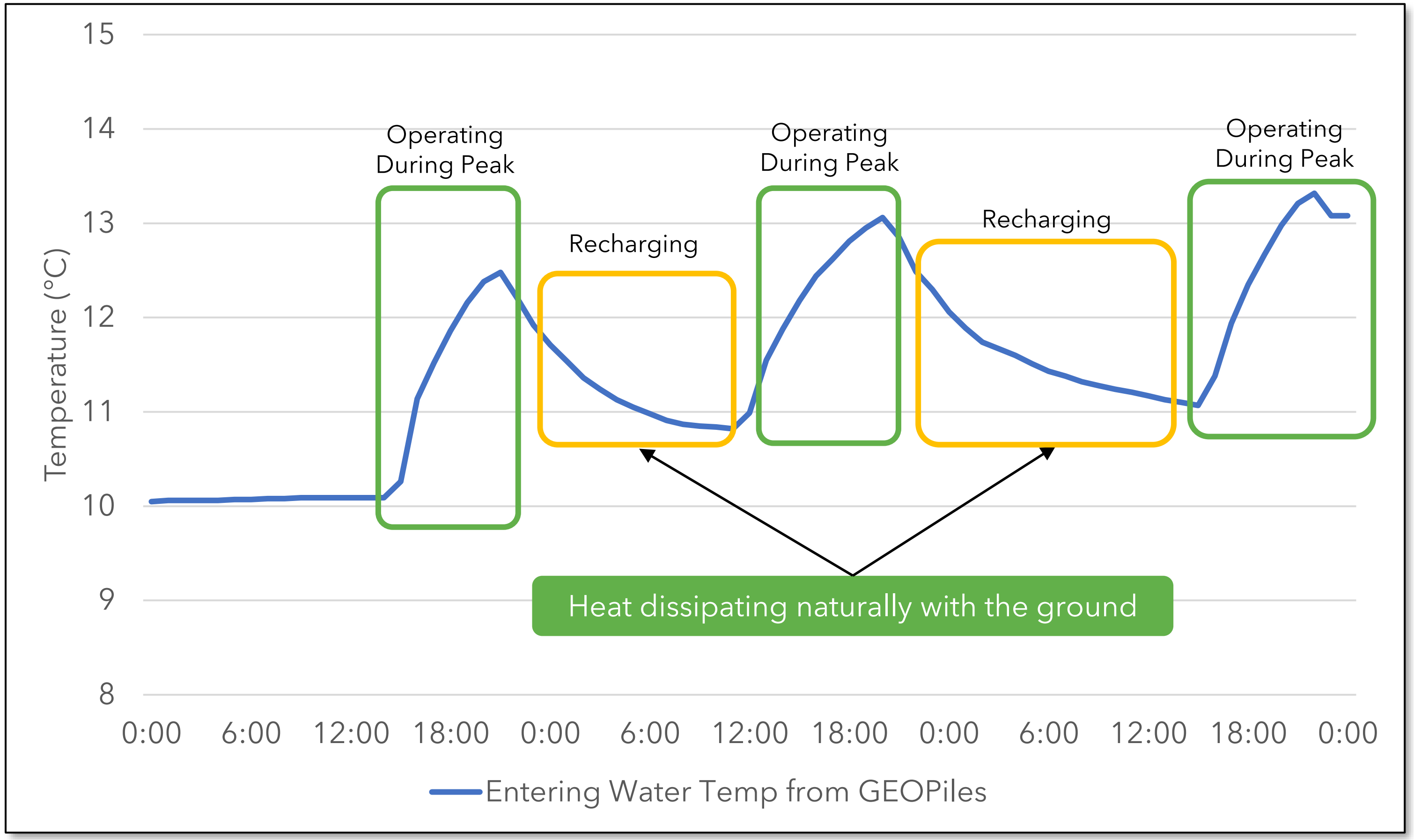


Pile Array was able to operate at 6 Tons for several hours (3 times the steady-state rating of 2 Tons)

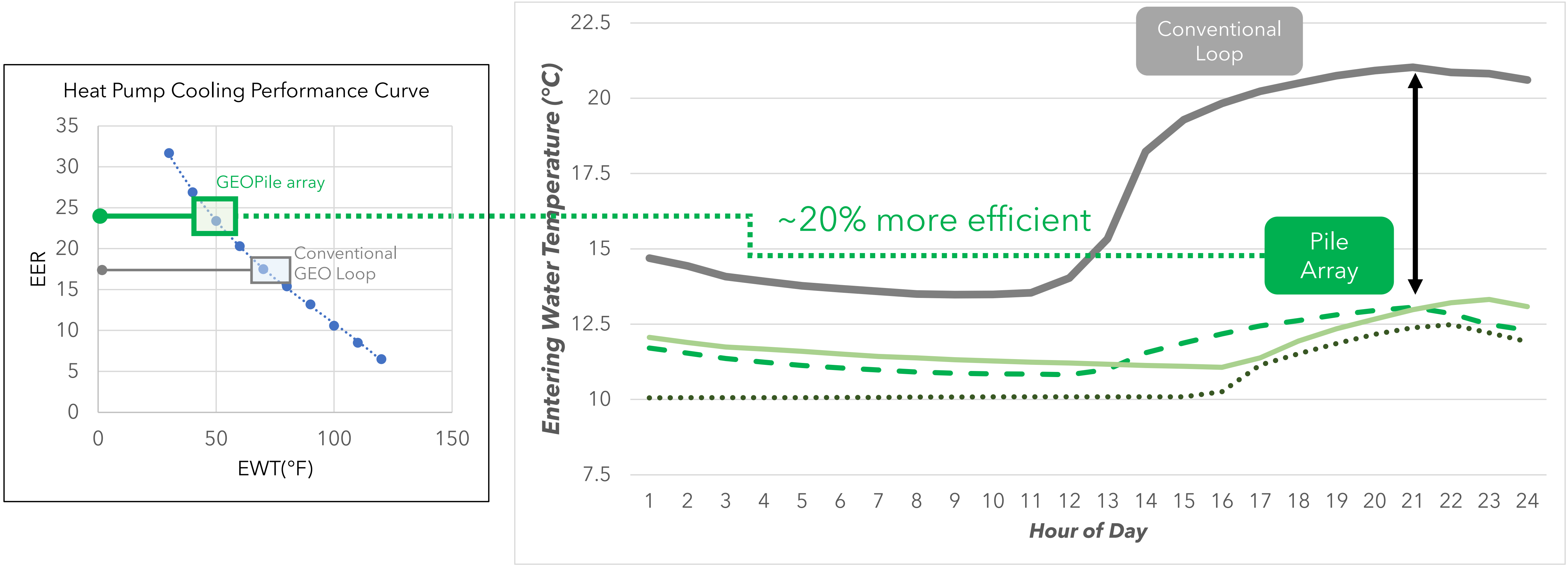
Example: "Recharging" Property



On/Off Test
3 consecutive hot summer days



Example: Performance vs Conventional Loop



- ***June 9 - Ground Loop***
  - High – 30°C
  - Low – 17°C
- ***June 4 - GEOPiles***
  - High – 27°C
  - Low – 13°C
- ***June 5 - GEOPiles***
  - High – 30°C
  - Low – 19°C
- ***June 6 - GEOPiles***
  - High – 31°C
  - Low – 18°C

Results

Objective 3: Comparison versus alternative HVAC systems

Type	Detached Home
Location	SW Ontario
Description	2,000 sq ft
System Size	2 Tons

Energy and Emissions Reductions

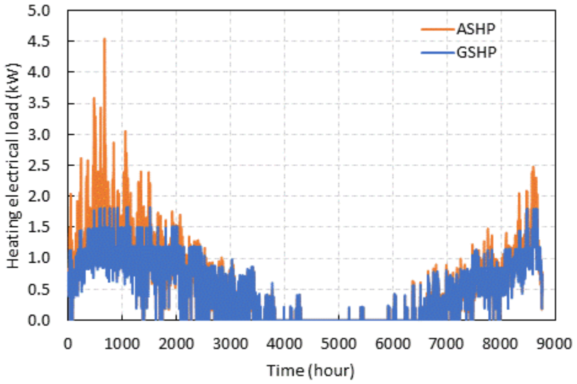
	GEOPiles vs Gas + A/C	GEOPiles vs ccASHP	ccASHP vs Gas + A/C
Energy Reductions (ekWh)	11,428	3,091	8,337
Energy Reductions (%)	72%	42%	53%
GHG Reductions (T CO_2e)	2.6	0.1	2.6
Emissions Reductions (%)	96%	42%	92%
Annual Cost Savings	$407	$402	$5

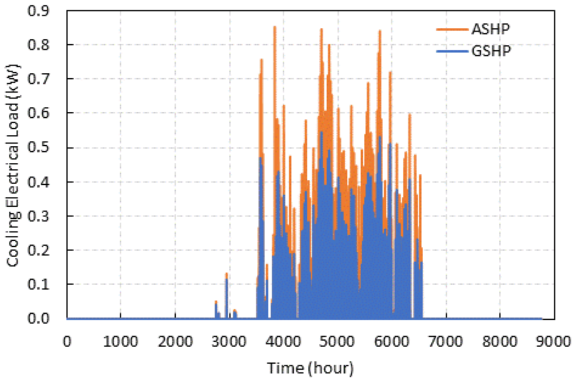
Results

Objective 3: Comparison versus alternative HVAC systems

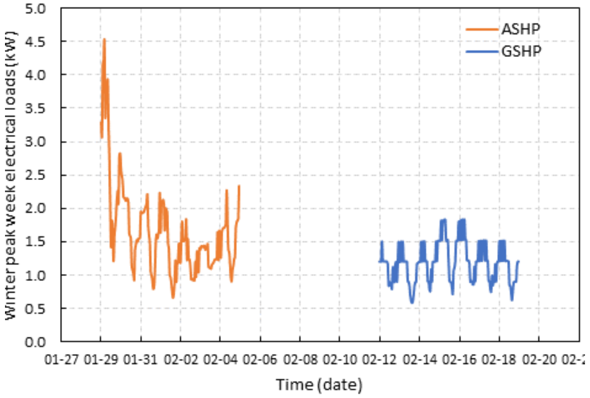
Electrical Load Comparison: GSHP vs ASHP

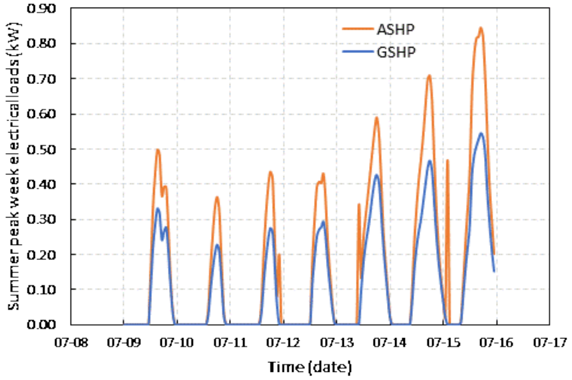
Annual Hourly Electrical Demand





Peak Heating and Cooling Weeks





	ccASHP	GSHP
Peak Winter Load	4.51 kW*	1.83 kW
Peak Summer Load	0.85 kW	0.54 kW

*The selected ccASHP was unable to meet the peak heating load due to capacity reductions from cold temperatures during the peak heating time. If a backup electrical resistance heating system were to be utilized, the peak winter load would exceed the value shown here.

Research collaboration next steps

Achievements:

1. 3X research papers published
2. 3X research papers under review for publication
3. 3X successful master's theses
4. Received multi-year $300k NSERC/Mitacs research grant
5. Supported research of 3X undergrads, 4X master's, 1X PhD, and 3X post-docs

Current Research Objectives:

1. Modeling techniques to expedite system analysis
2. Control strategies to beneficially utilize peaking and recovery properties
3. Integration with other resources to utilize thermal storage of large fluid volume
    1. Active collaboration with University of Calgary to analyze integration with Solar PVT panels
    2. Plans to analyze integration with drain heat recovery systems and radiative cooling panels