Commissioning Geothermal Systems

Kenneth Von Bank, PE, CCP
Mechanical Engineer
Sustainable Engineering Group LLC
Learning Objectives

1. Gain a better understanding of the challenges of geothermal system design, installation, and operation.

2. Demonstrate the ability to incorporate the knowledge of geothermal systems into all phases of the commissioning process.
Assumptions

- Geothermal system has been shown to be the “best fit” for the project through a Life Cycle Cost Analysis or similar

- Geothermal feasibility study has been performed
Energy From the Earth/Sun

- Earth = solar battery
- Absorbs nearly half of the sun’s energy.
- The ground stays a relatively constant temperature
- Warm heat source in winter
- Cool heat sink in summer
The earth is like a solar battery absorbing nearly half of the sun’s energy.
The ground stays a relatively constant temperature through the seasons, providing a warm source in winter & a cool heat sink in summer.
Ground-Source Heat Pumps

GSHP

• A term applied to a variety of system components that use the ground, groundwater, or surface water as a heat source and sink.

Also Known As:

• Ground-Coupled Heat Pumps (GCHP)
• Ground-Water Heat Pumps (GWHP)
• Surface Water Heat Pumps (SWHP)
• Direct Expansion (DX) GCHP
Ground Coupled Heat Pumps (GCHP)

Closed-loop ground-source heat pumps

- Reversible vapor compression cycle
- Closed ground loop heat exchanger
- Water or Water/antifreeze solution

Most common type → Water-to-air heat pump
Focus on Geothermal Field:

• Once the system is buried, it should remain buried for 50+ years.

• Repairing geothermal systems is difficult and costly after the system has been backfilled.

• Proper design, installation, and Cx will minimize the chances that the buried system will need repairs.
Type of ground heat exchanger design

- Vertical vs. Horizontal
- Hybrid System
Advantages of Vertical GCHP

• Requires relatively small plots
• Soil varies very little in temperature and thermal properties
• Requires smallest amount of pipe and pumping energy
• Can yield the most efficient GCHP system performance
Disadvantages of Vertical GCHP

Higher cost because of equipment needed to drill borehole

- Drill Rig
- Grout
- Grout Mixer

Limited experienced contractors
Horizontal GCHP

Advantages

• Less Expensive than vertical GCHP
• Residential applications have adequate ground area
• More trained equipment operators

Disadvantages

• Larger Ground area requirement
• Greater adverse variations in performance
  ○ Ground Temperatures
  ○ Rainfall
  ○ Burial Depth
• Higher Pumping-Energy Requirements
• Lower System Efficiencies
Commissioning Phases

• Planning
• Design
• Construction
• Occupancy/Operations
Commissioning Phases

Part 1: Planning Phase
Planning Phase

• Approval from DNR or other governing body or Authority Having Jurisdiction (AHJ)

• Formation & Thermal Conductivity (TC) Test to determine ground properties
Field Tests

- Drill to desired depth
- Use same pipe diameter and grout
- Wait 5 days
- Insulate entire device
- Minimum test length = 48 hours
Thermal Conductivity Test

Advantages
- Accurate borefield size
- Indicates level of effort required to insert loop
- Type of drilling
- Reduce Contractor’s uncertainty
- May reduce bid price
- Can use test bore in design

Disadvantage
- Initial cost
- Results can be inaccurate
F&TC Test Report

- Copy of Drill Log
- Ground Thermal Conductivity (Btu/h·ft·°F)
- Ground Thermal Diffusivity (ft²/day)
- Undisturbed Ground Temperature (°F)
- Depth to Water Table
Water Problems
Commissioning Phases

Part 2: Design Phase
Design Review: What to Look For…

- Qualifications: Geothermal contractor certified by IGSHPA
- As-built drawings of geo field required (including GPS coordinates)
- F&TC Test results
- Contractor to integrate test bore into the geothermal field
• Pipe and fittings shall be HDPE classified for geothermal installation (IGSHPA)
• 50 year warranty provided by pipe manufacturer
• Heat transfer fluid must be approved by DNR or State Regulatory Agency
• Locating Wire and Warning Tape
• Thermal Grout: TC of at least 1.0 Btu/hr-ft-F (obtain samples for testing)
Thermally Enhanced Grout

200-Ton, 300' deep Vertical System

Grout Conductivity (Btu/h ft °F)

Bores

0.45 0.6 0.85 1 1.2
![Design Review: What to Look For…](image)

**Header Pit Vault**

- HDPE classified for geothermal installations
- Factory pressure tested – no leaks at 1 psi air test for at least 30 minutes
- Entry to vault – minimum 28” diameter, neoprene gasket on lid, traffic rated frame and cover if located in traffic area.
- Ladder – Conform to current OSHA guidelines
- Anti-buoyancy calculations – amount of concrete needed to anchor vault
- Valves: Isolation valve on supply line of each circuit. Balancing valve on return line of each circuit.
- P/T port on each supply and return main and all circuit pipes
Vault Installation
Header Pit Vault

- Circuits routed to underground vault
  - Typically 3” Dia Circuits
  - Balancing Valves
- Only two pipes go back to building
- Concrete vs HDPE
  - Concrete cheaper
  - HDPE water tight
Design Review: What to Look For…

• Pressure Testing
• Flushing and Purging
• Grouting
• Backfilling
Borefield Design

• Minimum bore spacing
• Bore depth
• Reverse Return piping configuration
• Minimum burial depth of lateral pipes (based on frost layer depth)
Frost Layer
Example: 100 Bore System
Circuit

Below Grade in Sand Bedding
Reverse Return – Balanced Flow
Commissioning Phases

Part 3: Construction Phase
Construction Verification

Before Excavation Begins

- Contractor Qualifications
- Shop drawings must be approved prior to ordering materials or starting work
- Site Erosion Control Plan in place
- DNR and/or State Regulatory Agency approval

*Timing is critical*
Construction Verification

During Excavation / Drilling / Pipe Installation

- Bore spacing / depth
- Materials on site: pipes, grout, backfill materials, vault, etc.
- Lateral pipe (trench) depth – below frost line
- Grouting Procedure
  - Must grout within 24 hours of drilling. No more than four un-grouted boreholes at any one time.
  - Test grout mixture samples early.
- Seal open ends of pipes to prevent entry of contaminants

*Timing of verification is critical*
Open Pipe Ends
Construction Verification

Prior to Backfilling

- Pressure Testing successful and witnessed
  - Test with water, NOT air
- Flushing and Purging successful and witnessed
  - At least 2 ft/sec to remove air and debris
- Bedding material (sand) is free of rocks, clay, and sharp objects
- Locating wire installed on pipes
- Location of bores and pipes have been surveyed – as-built drawings are accurate

Did I mention that timing of verification is critical?
Unapproved Pipe Bedding
Construction Verification

During Backfilling

- No backfilling in freezing weather or with frozen materials
- Warning tape installed approximately 36” above pipes
Commissioning Phases

Part 4: Occupancy/Operations Phase
Borefield is essentially maintenance-free
Verify glycol concentration
Verify system pressure
Check fluid temperatures – range of 30F to 100F is normal
Annual check of vault interior (if applicable)
Cooling & Heating EWT - Efficiency
EER & COP

EER = Energy Efficiency Ratio

- Cooling Mode
- Typical Range 18-27 EER

$$EER = \frac{Cooling\ Output\ (Btu/hr)}{Electrical\ Input\ (W)}$$

COP = Coefficient of Performance

- Heating Mode
- Typical range 2.8-4.0 COP

$$COP = \frac{Heating\ Output\ (Btu/hr)}{Electrical\ Input\ (Btu/hr)}$$
Resources


5. Wisconsin Department of Natural Resources. [http://dnr.wi.gov](http://dnr.wi.gov)

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THANK YOU

Kenneth Von Bank, PE, CCP