

The Entropy Police

Geothermal heat pump design program and cost
benefit analysis

Colin Ryan
Mitchel Gogert
Samuel Qualls
Desiree Reed

Problem Statement

- St Gertrude's Monastery currently runs off of a coal fire boiler, however the Sisters want to move to a more a reliable, economical, and environmentally friendly heat source.

Client's Needs

- A system that would cost ~ \$750,000
- Environmentally friendly
- Building does not require cooling
- More reliable system
- Does not require changing heat delivery system
- Cost benefit analysis to current system

Objectives

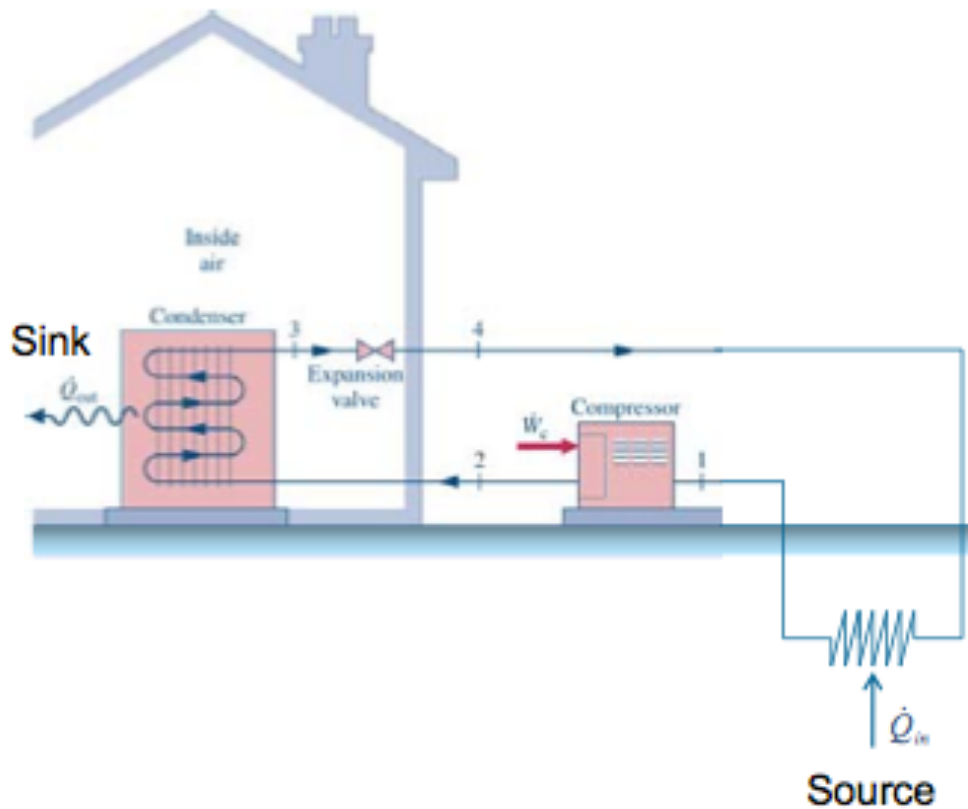
- Develop an EES computer model/program that can be used to design and optimize geothermal heat pump systems for residential buildings, including a cost benefit analysis.
- Compare cost benefit analysis for several other alternatives
 - Coal fire
 - Biodiesel
 - Hydroelectric
 - Biomass

Why Geothermal?

- Environmentally friendly
- Fairly sustainable
- High initial cost, low operating cost (65-70% less than traditional systems)
- Federal and state tax credits
- Single system for heating and cooling; in some cases hot water heating

Results of Project Learning to Date

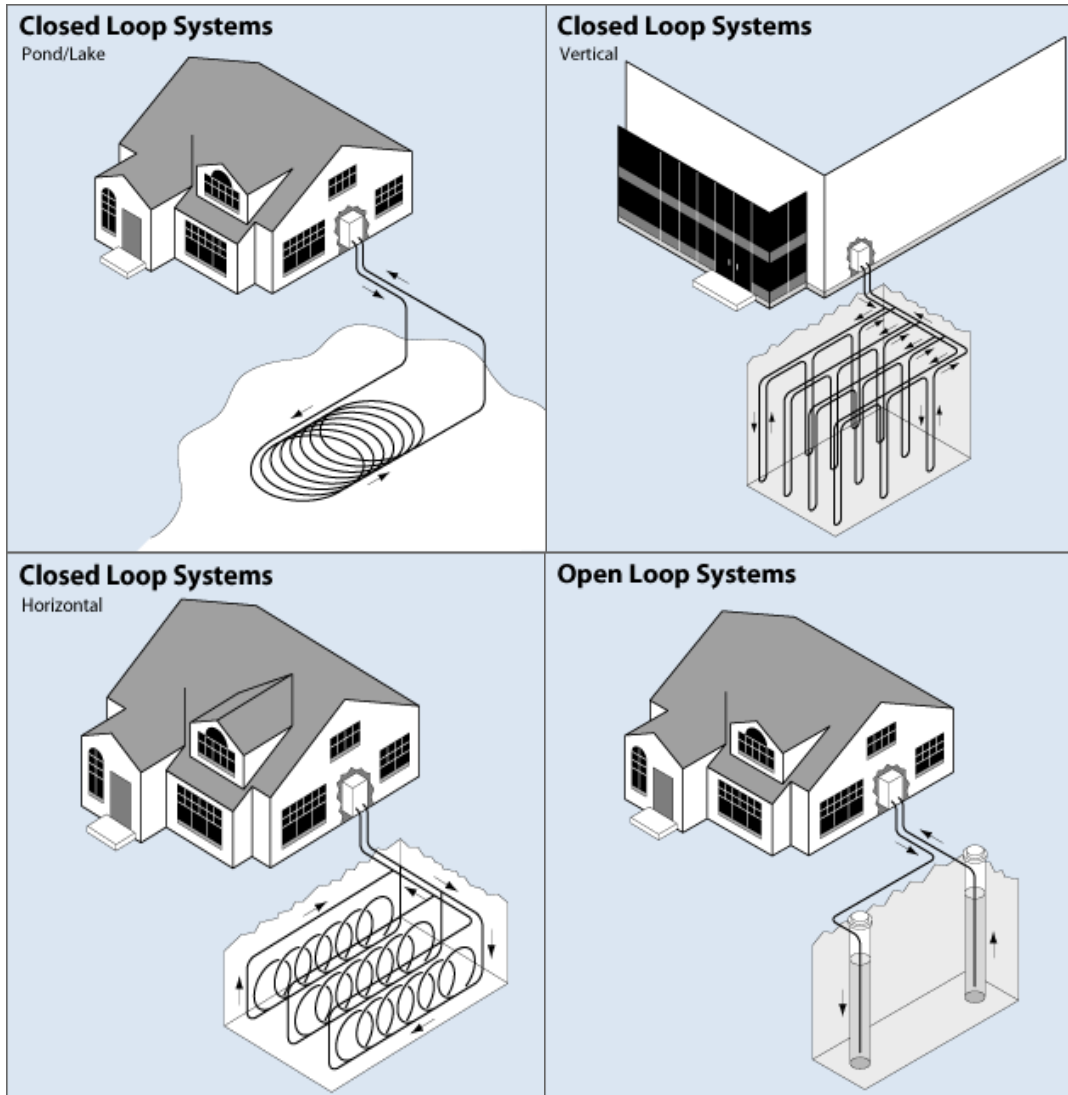
Isothermal heat pump



- Q_{in} is the heat input via isothermal ground temperatures
- Q_{out} is the heat delivered to the building from the heat pump
- W_c is external power provided to the system to operate

This system heats in the winter because the ground temperature is higher than the outside air. This is the opposite in the summer. Heat pumps have the ability to run in multiple directions and therefore, can be used for heating and air conditioning.

Results of Project Learning to Date



Types of heat pump systems that are commonly used in industry.

Closed Loop

- Pond/lake
- Vertical
- Horizontal

Open Loop

- Each system has varying benefits and drawbacks, which is seen in pricing, space, and efficiency.

Pricing (lowest to highest)

- Open loop
- Pond/lake
- Horizontal
- Vertical

Table of Specifications

- Maximum heating load per month is 261 MBtu.
- Yearly total is 921.7 MBtu.
- Building square footage: 49485 ft².
- Ground temperature 64° F, water temperature 52° F.
- Frost line approximately 18”.
- Water going to radiator system needs to be at least 100° F.

Approach and Deliverables

- Develop an EES program and validate it using existing data for an existing system. We will be working closely with a PE in the geothermal business who will provide project guidance.
- Use the EES program to design a geothermal system for the monastery with cost benefit analysis of varying loop configurations.
- Evaluate other alternatives for the monastery.

Time Line

- October 31st – Finalized scope of work
- November 14th – Model of heating load
- November 28th – System model validation
- December 5th – Cost benefit analysis
- December 12th – Written report to client
- April 3th – Software development
- April 24th – Optimized system design
- May 2nd – Design expo
- May 9th – Final report