In-Depth:
Geothermal Heat Pumps

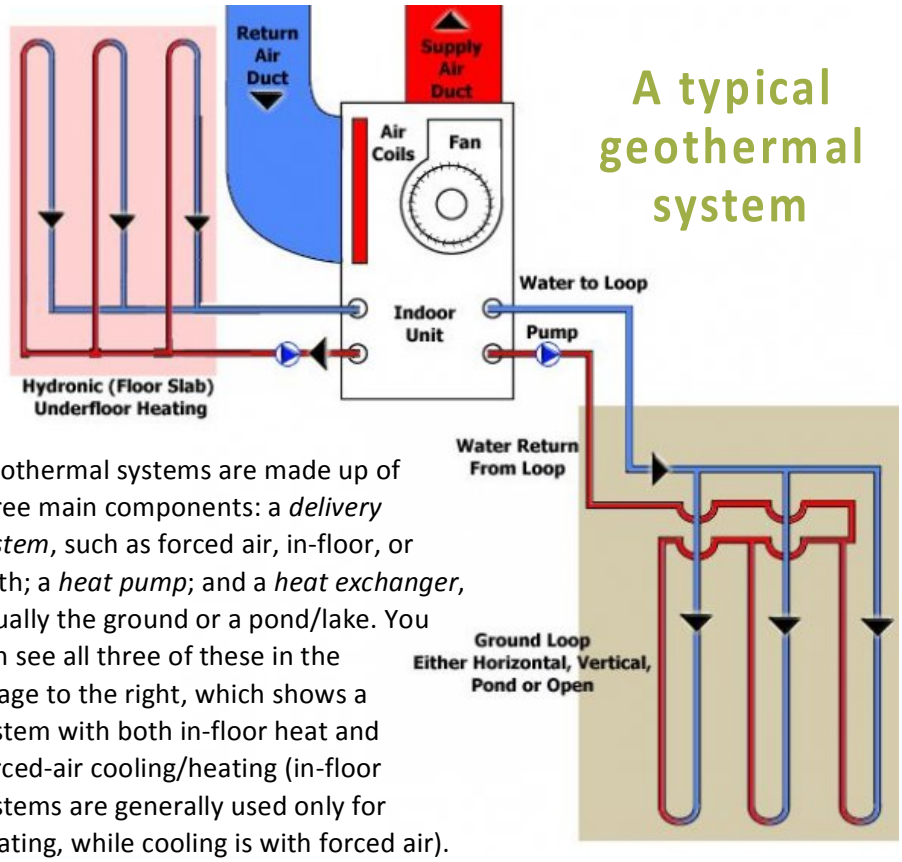
Cascade Meadow
Wetlands & Environmental Science Center

Could a geothermal system save you $$?

Heat pump systems are generally considered appealing because they allow us to make use of the consistent temperatures of the ground (or in the case of Cascade Meadow, a lake) to help a heating and/or cooling system work more efficiently. In theory, this should allow for reductions in both overall energy consumption and the emissions (carbon and otherwise) associated with energy generation and consumption. In practice, the heat pump story is a little more complicated.

With a lot of firms and contractors vying for geothermal system sales and installation, messages about geothermal can become oversimplified. In Minnesota, a geothermal heat pump system *can* save energy and result in fewer emissions if it is used to replace *both* the heating and cooling load in a home or business. Using a geothermal heat pump system *just for heating* doesn't always make sense, except in certain situations, (e.g. when the heat pump is replacing all-electric heat).

Each site and building is unique, as are the situational factors that impact the decision to install a heat pump system (such as available energy sources and their costs). This sheet provides details for the geothermal heat pump system installed at Cascade Meadow and answers some of the basic and not-so-basic questions that arise when considering the purchase of a heat pump system. Be sure to consider all the factors before committing to a switch to geothermal.



A typical geothermal system

Geothermal systems are made up of three main components: a *delivery system*, such as forced air, in-floor, or both; a *heat pump*; and a *heat exchanger*, usually the ground or a pond/lake. You can see all three of these in the image to the right, which shows a system with both in-floor heat and forced-air cooling/heating (in-floor systems are generally used only for heating, while cooling is with forced air).

A heat pump is very similar to the refrigerator in your kitchen. Using a compressor with a refrigerant gas, the heat pump moves heat from one place to another. Just like a refrigerator, heat pumps run on electricity, and they can use quite a lot of this resource. What makes them better than refrigerators is that heat pumps exchange heat not with the air, which can reach extremes of both hot and cold (-30° to 110° in MN), but with the ground (below 4 feet) or with a lake or pond. Temperatures there, unlike those of the air, remain quite moderate throughout the year (between 38° and 80° in MN). By exchanging heat with the ground or a lake, heat pumps can be a very efficient way to heat and cool a building.

How are the heat pumps at Cascade Meadow set up?

Cascade Meadow's system involves three parts: a heat exchanger and two heat pumps, both of which perform specific functions as a part of the heating, ventilation, and air conditioning (HVAC) system.

Heat Pump 1 works with the building's air-handling unit. It works in both "directions," moving heat from the lake into the building in winter and from the building to the lake in the summer. In the summer, this heat pump takes care of all the building's cooling demands. In the winter, it pre-heats the outside air that gets pulled into the air handler before heading out to the ventilation system of the building.

Heat Pump 2 is tied into both the building's in-floor heating system and the air re-heat boxes that target specific spaces in the building. It works only in the heating "direction," moving heat from the lake into the building.

The Heat Exchanger

Buried under the shore of the lake is a manifold where the pumped fluid (a mixture of water and non-toxic anti-freeze) splits out to 4 "sleds" of coiled plastic tubing. The size of a geothermal sled is measured in "tons" and our four sleds are all 4-ton sleds. Each sled has hundreds of feet of coiled tubing through which the water-antifreeze mixture gets pumped.

What does a typical geothermal heat pump system cost?

Because every site and situation is different, the costs for geothermal heat pump systems can vary significantly. Cascade Meadow recommends two resources for exploring the cost of a geothermal system. The first is a case study reported by MN Clean Energy Resource Teams (MN CERTs). The case study details the costs of a SE Minnesota homeowner's geothermal heat pump system installed in 2009. Including installation and both power company incentives and federal tax credits, the case study reports a cost of $14,000 for the residential geothermal heat pump system ($21,000 without incentives). While these numbers should not be considered typical, they can give a ball-park figure to someone interested in exploring a geothermal heat pump system.

Conventional System Costs per Square Foot

Costs per Square Foot	Annual Maintenance	Total Installed Costs - New Construction	Total Installed Costs - Existing Building
Small Office	$ 0.27	$ 16.00	$ 17.00
Large Office	$ 0.15	$ 24.00	$ 25.00
Small School	$ 0.29	$ 24.00	$ 29.00
Large School	$ 0.10	$ 24.00	$ 29.00
Small Residential	$ 0.14	$ 5.50	$ 5.80
Large Residential	$ 0.08	$ 4.90	$ 5.15

GHP System Costs per Square Foot

Costs per Square Foot	Annual Maintenance	Total Installed Costs - New Construction	Total Installed Costs - Existing Building
Small Office	$ 0.26	$ 28.50	$ 31.50
Large Office	$ 0.12	$ 28.50	$ 31.50
Small School	$ 0.23	$ 28.50	$ 33.50
Large School	$ 0.08	$ 28.50	$ 33.50
Small Residential	$ 0.16	$ 12.50	$ 12.80
Large Residential	$ 0.10	$ 11.10	$ 11.35

The second resource Cascade Meadow recommends is the report, "Performance, Emissions, Economic Analysis of Minnesota Geothermal Heat Pumps." While highly technical, it provides a clear and complete review of the many factors that should concern those considering a geothermal heat pump system for their home or business. With regard to cost, the two tables above summarize the results of their Minnesota-wide survey of geothermal heat pump installers. The entire report is available on the firm's website (see Additional Resources on next page).

Is a geothermal system right for you? Conduct a feasibility study.

Geothermal systems won't work for everyone or every site. Deciding if it's right for you and for your site involves careful thought and preparation. Going through the questions and steps below – your feasibility study – will help you make the right choice. In the end, if your site is one where a geothermal system presents too many challenges, consider purchasing renewable power from your power utility, become an advocate for large-scale renewable energy projects, and/or look into another renewable energy system such as solar thermal, solar-photovoltaic, or small wind.

1. Explore your motivation: Why do you want a geothermal system? Are there simpler or cheaper ways to reach your goals?
2. Know your site: Does your site have the appropriate geology or hydrology to support a ground-source or lake-source heat pump? Are there other practical or physical limitations?
3. Research zoning/permitting: What local zoning or permitting rules (including ordinances) affect your site?
4. Research the equipment: Once you've answered 1-3, research the available heat pumps and other equipment that meet your needs. Proceed carefully, as there are many options and configurations with differences in the complexity and equipment required.
5. Choose an installer: Get recommendations from others in your area who have used renewable installers, and learn as much as you can before you commit. See more on this below.
6. Work with your utility: Know the applicable laws that affect you and your utility. Keep in mind that your utility has its own interests to consider.
7. Insure your investment: This detail is often overlooked; consider protecting your investment with insurance.
8. Know the maintenance costs: Be aware of costs for heat pumps, fluids, tanks, and other pumps.

Additional resources

- To learn about geothermal incentives and rebates:
  - Rochester Public Utilities offers its customers a geothermal rebate program. Find out more about the program in the Conserve & Save Electric Efficiency Application (p.7) at www.rpu.org/your-home/rebates-programs/conserve-and-save.html.
  - For a comprehensive and up-to-date list of federal, state, and local incentives and rebates, head to www.dsireusa.org.
- To find qualified local vendors, consultants, and installers:
  - The Minnesota Department of Commerce, Energy Division maintains a resource page for ground source heat pump systems. Find it at mn.gov/commerce/energy/topics/clean-energy/Ground-Source-Heat-Pumps.jsp.
  - Technical Report for MN: Read the report "Performance, Emissions, Economic Analysis of Minnesota Geothermal Heat Pumps" at www.michaelsenergy.com/2010/06/minnesota-geothermal-heat-pumps.
- To learn more about the Cascade Meadow geothermal system, ask a staff person or representative to show you the trend and live data from the geothermal system, or find it on our website at data.cascademeadow.org.

Learn More

Cascade Meadow's website provides lots of additional information about various sustainability technologies. Visit www.cascademeadow.org for more details, and watch the website's Events page to learn about upcoming workshops and events that can help answer your sustainability questions.

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