GREAT PLAINS INSTITUTE

Climate-Friendly Heating and Cooling for Local and Tribal Governments

A Guide to Implementing Geothermal in Minnesota

JANUARY 2026

Partner organizations:

CERTs CLEAN ENERGY RESOURCE TEAMS

HENNEPIN COUNTY MINNESOTA

GREAT PLAINS INSTITUTE

Acknowledgments

This guide would not have been possible without the generous support of the Urban Sustainability Directors Network Catalyst Fund and the McKnight Foundation. The project partners include Hennepin County, Clean Energy Resource Teams (CERTs), and the Great Plains Institute (GPI). The funding supported a learning group workshop series with Minnesota local governments and the development of this guide.

From August to December 2025, 68 participants attended six workshops (participants consisted of 41 entities, including cities, counties, state agencies, and other organizations). We thank the workshop participants who committed time to the learning series, shared their perspectives and experiences, suggested additions to the guide's content, and reviewed this guide.

The content communicated and shared in the workshops was heavily referenced to generate the information in this guide, and broad attribution is given to these contributors. Workshop guest speakers included representatives from communities that have implemented projects (Eagan, Plymouth, Rochester, St. Louis Park, and Saint Paul), Noah Cordoba from the Building Decarbonization Coalition, and Brian Urlaub with Salas O'Brien engineering and technical services firm, a member of the International Ground Source Heat Pump Association. GPI staff, with contracted support from Alexis Troschinetz of AMT Consulting LLC, authored this guide.

GREAT PLAINS INSTITUTE

Contents

Introduction

Ground source heat pump technology continues to advance and evolve, reaching new levels of efficiency and implementability. This guide aims to orient Minnesota cities, counties, schools, and tribal nations on ground source (also referred to as geothermal) heat pump systems for heating and cooling buildings, so local governments can benefit from these advancements. This guide offers introductory information on the following:

- Common system types implemented by local governments
- Individual benefits and community impacts
- Process for implementing individual and networked systems
- Funding and financing strategies for these projects

Ground source heat pump systems are an appealing pathway for local governments to accomplish climate goals while investing taxpayer dollars responsibly. These systems rely on proven technologies with long equipment life that reduce buildings' operating costs. Heat pumps are one of the most efficient ways to mechanically heat and cool buildings. By electrifying some of a community's building heating and cooling needs, reliance on fossil fuels is reduced when that electricity is generated with renewable energy.

Local and tribal governments can lead by example in their communities by implementing and encouraging ground source heat pump systems. Many local and tribal governments begin with a system for one of their own public facilities, which is why this guide focuses on systems for individual buildings.

Once a local government has gained experience with the technology on an individual building, it may progress to connecting two or three buildings to explore facets of a networked system. In time, a local government may take a lead in implementing geothermal networks where numerous buildings are connected to one system. Some cities in Minnesota (Rochester, St. Paul, Minneapolis, and Duluth) and utilities are starting to explore these community-scale networks. This guide offers limited information on geothermal networks to inspire communities to consider them in the future.

Geothermal energy has a technical and historical basis in referring to the Earth's very high temperatures, found thousands of feet below the surface.[1] The federal government's information on geothermal energy focuses on geothermal direct use and geothermal power generation, with light mentions of ground source heat pumps. The International Ground Source Heat Pump Association (IGSHPA) offers a good explanation of the spectrum of geothermal energy sources. *Geothermal energy* has become an umbrella term for subsurface thermal energy, whether shallow or deep.

The term **ground source heat pumps** more accurately represents the energy source and technology. This guide may occasionally refer to *geothermal energy*, but generally uses the term *ground source heat pump*. This guide uses the term **geothermal network** to briefly indicate that network systems utilize thermal energy from the ground. IGSHPA provides a comprehensive list of industry acronyms and terminology.[2]

Some local governments may choose to encourage ground source heat pump systems with private developers, as these projects are typically more frequent than public projects. This guide does not offer specific resources on ground source heat pumps for private developers, but much of the information still applies.

Overview

Ground source heat pump (GSHP) systems move thermal energy between the ground and the indoor air of the buildings to which they are connected. Despite the terms GSHP and geothermal energy containing the words *heat* and *thermal*, these systems can be used to both cool and heat buildings.

In Minnesota, starting at depths of 6 to 8 feet underground (i.e., below the *frost zone*), the ground temperature is always 48–52 degrees Fahrenheit.[3] The constant ground temperature acts as a *thermal battery.* In the summer, the ground holds thermal energy from a building's indoor air, acting as a *heat sink* and providing cooling. In the winter, the ground releases thermal energy to a building's indoor air, acting as a *heat source* and providing heating.[4]

There are many GSHP system configurations, but all setups include heat pump equipment inside the building(s), circulation pumps, sensors and controls, and a ground heat exchanger.[5]

Ground Heat Exchangers

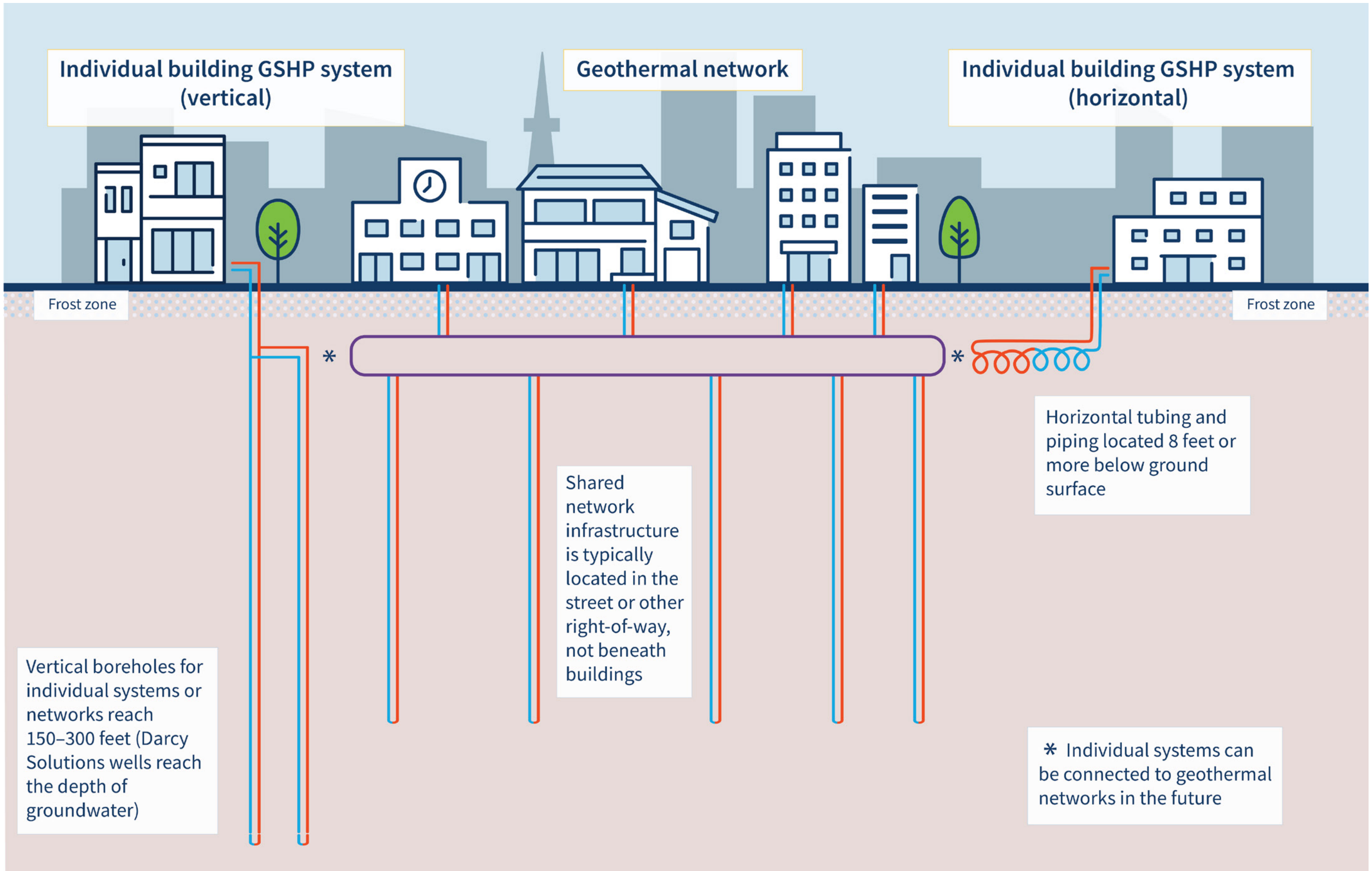
A ground heat exchanger is the part of a GSHP system located underground that is responsible for exchanging thermal energy with the ground, groundwater, or surface water.[6] Ground heat exchangers have many variations depending on the energy requirements (also referred to as a building's heating and cooling *loads*), the system's outdoor layout, and the technology selected. There are two types of ground heat exchangers: closed-loop and open-loop.

CLOSED-LOOP SYSTEMS

Closed-loop installations are currently most common in Minnesota and can be configured horizontally or vertically, depending on available area on-site for the ground heat exchanger. Closed-loop systems involve the circulation of heat transfer fluid (water or refrigerant) through pipes or tubing. Therefore, the soil, groundwater, or surface water does not come into direct contact with the heat transfer fluid.[7]

Figure 1 illustrates closed-loop ground heat exchanger configurations for individual buildings and for multiple buildings on a single system (geothermal networks).

Figure 1. Closed-loop ground heat exchanger configurations



Source: GPI illustration based on information derived from workshops (see Acknowledgments section).

In horizontal closed-loop systems, pipe or tubing is laid out in rows or in coils in relatively shallow open-pit excavations[8] or wide trenches two or more feet below the frost zone, which is 6 to 8 feet deep in Minnesota. The excavation footprint is approximately 500 square feet per ton of heating and cooling system capacity. Horizontal systems can also be installed in a pond or other body of water.[9]

In vertical closed-loop systems, wells (also referred to as *boreholes*) are typically drilled 150 to 300 feet deep and spaced about 15 to 25 feet apart, depending upon the site's geology. Each borehole contains one or more single loops of pipe with a U-bend at the bottom. Each vertical pipe loop is connected to a horizontal header piping system that is buried in an excavated trench that is 8 to 10 feet deep. It is estimated that each borehole provides 1 to 1.5 tons of heating and cooling system capacity. Therefore, numerous boreholes are needed to meet the heating and cooling loads of typical public facilities.[10]

A vertical closed-loop option that is gaining popularity in Minnesota, due to occupying less site area, is Darcy Solutions. Vertical wells are drilled to depths that reach groundwater, which is typically hundreds of feet deep in Minnesota. The wells contain heat exchanger equipment submerged in the groundwater, resulting in heating and cooling of the groundwater as it flows by, instead of the ground like other closed-loop systems.

Darcy Solutions wells access 20 to 50 times more thermal capacity than a conventional vertical borehole[11] or possibly 20 to 75 tons of heating and cooling system capacity, depending upon the site's aquifer characteristics. Therefore, significantly fewer Darcy Solutions wells are required than for a conventional vertical GSHP system. Each Darcy Solutions well requires approximately 8 feet by 30 feet of site area. While the wellhead does not occupy much space, dedicated space for truck access is required. When multiple Darcy Solutions wells are installed at one site, wells are spaced 100 feet apart.

Geothermal networks, also called *networked geothermal*, interconnect multiple buildings on a shared horizontal piping system (or *ambient loop*) and utilize thermal energy from the ground. Geothermal networks are designed "with the intent of optimizing the various building loads to reduce the overall size of the loop" and ground heat exchanger.[12] Any ground heat exchanger can be used with networked geothermal, but vertical borehole closed-loop systems are the most common. Figure 1 illustrates this common configuration.

Geothermal networks are a type of *thermal energy network* (TEN). TEN is the broader term that refers to any system where thermal energy is shared among buildings at a neighborhood scale. Geothermal networks specifically access the stable temperature of the earth.[13] Local governments may also be engaged in UTENs, or utility thermal energy networks, which are networks built and maintained by utilities.

District energy systems, dating back to the late 1800s, typically rely on fossil fuels. However, it is becoming common for new or revamped systems to have their central plant energy source be geothermal. Only the latest generation of district energy systems has similar characteristics to a TEN.[14]

With networked geothermal, much of the thermal energy comes from vertical boreholes that tie into the shared horizontal piping system, but some of it comes from the shared thermal resources of other buildings on the loop. Heat pump equipment is in each connected building to utilize the shared and ground source thermal energy.

By having a variety of building types on one system, for example, grocery and residential, some buildings will supply their waste heat to the system (grocery) while others will call for heat (residential).

Individual building GSHP systems can operate on their own until an adjacent network becomes available and then connect to it. Figure 1 illustrates this concept of individual systems being interconnected to networks at a future date.

OPEN-LOOP SYSTEMS

Open-loop systems have production wells that withdraw water from the aquifer and re-injection wells that put water back into the same aquifer. The thermal energy in the withdrawn water is used in the ground source heat pump system. To reduce pumping equipment maintenance, the use of groundwater that is low in minerals and fine soil types, such as silt, is necessary.

Open-loop wells are similar to traditional water supply wells and must be spaced according to the pumping rates and aquifer recharge characteristics. Wells may need to be spaced 50 feet or more apart, and two re-injection wells may be required for every production well, depending on the site's geology. To limit adverse chemical or temperature plume impacts to the groundwater, production and re-injection wells are typically placed hundreds of feet apart.

Open-loop systems offer significant heating and cooling capacity potential. Each production well may provide possibly 100 to 400 times the thermal capacity of a conventional vertical borehole and two to three times that of a Darcy Solutions well.

Regulations have recently changed in Minnesota, making open-loop systems more feasible than before. Successful implementation of these systems will depend on favorable site-specific geology, good water quality, and access to a large area. Figure 1 does not illustrate open-loop systems.

Table 1 provides a comparison of the different ground heat exchangers.

Table 1. Comparison of ground heat exchanger configurations

Type	Loop type	Estimated amount of site area needed for 50 tons capacity*	Depth
Horizontal piping	Closed loop	25,000 square feet (about half of a soccer field)	About 10 feet
Vertical boreholes	Closed loop	50 boreholes within 20,000 square feet (about one-third of a soccer field)	About 150–300 feet
Wells with submersed heat exchanger equipment (Darcy Solutions)	Closed loop	One well within 240 square feet	As deep as the groundwater is at the site, typically, hundreds of feet
Production and re-injection wells	Open loop	Not a good fit at this capacity; better for loads over 100 tons	As deep as the groundwater is at the site, typically, hundreds of feet

Source: GPI analysis based on information derived from workshops (see Acknowledgments section).

Note: * Assumes a public facility with a heating and cooling capacity requirement of 50 tons.

Heat Pumps

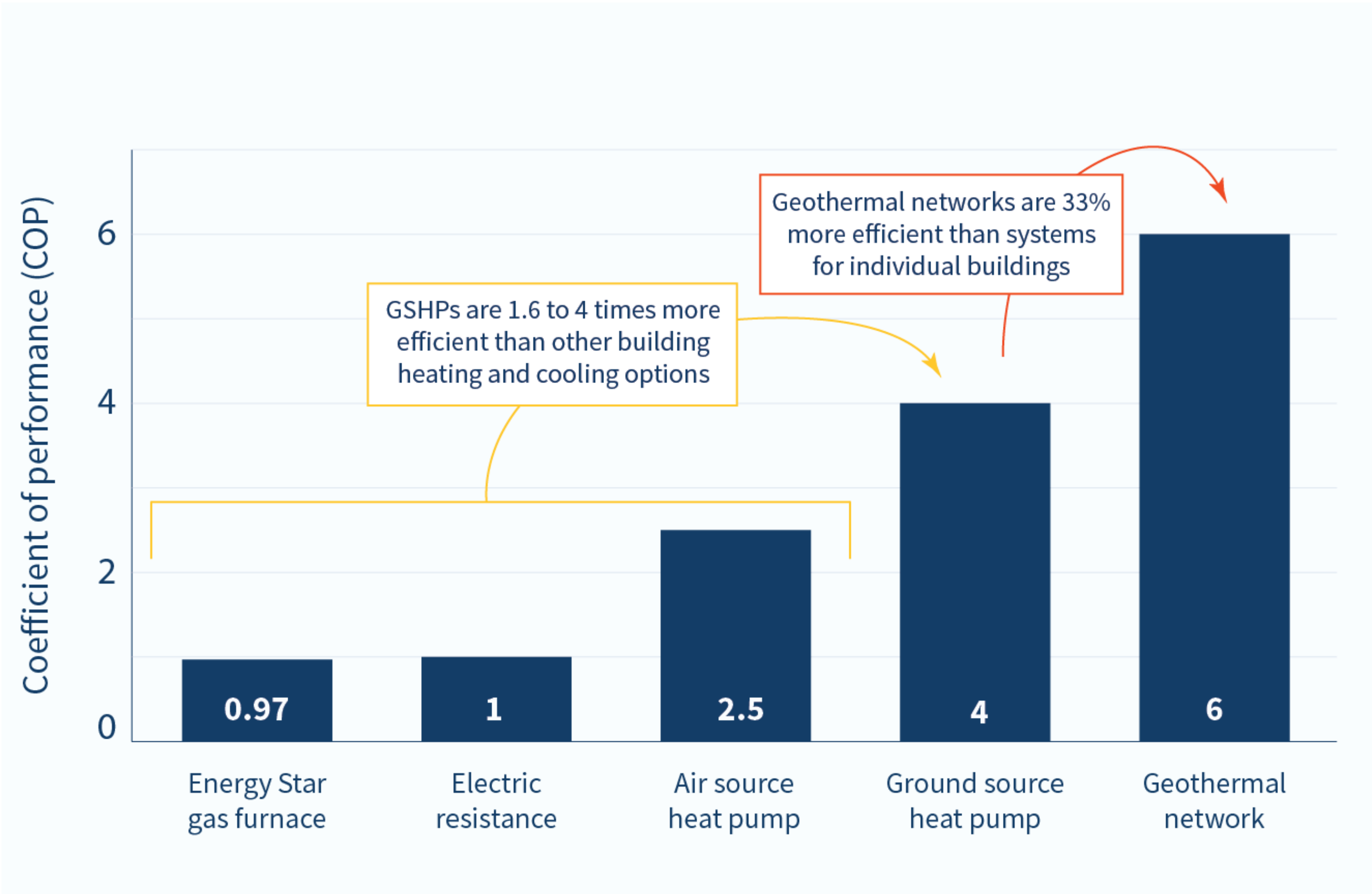
One of the key components of GSHP systems is what makes it so efficient—the heat pump equipment within each building. Heat pumps are one of the most efficient ways to mechanically heat buildings because they move heat instead of generating it. Heat pumps also cool buildings, similar to conventional air-conditioning systems.

GSHPs use relatively little electricity to move large amounts of thermal energy between the ground and buildings.[15] The ratio of the amount of energy a heating and cooling system can supply to the amount of energy required to operate it is referred to as the *coefficient of performance* (COP).[16] When COP is calculated over an entire year, it is called the *average COP*.

The bar chart in figure 2 shows the average COP for different building heating systems. GSHPs have a COP of four, which means they generate four units of heat energy for every one unit of electric energy required to run them.[17]

Compared to other heating systems, GSHPs are four times more energy efficient than forced-air furnaces and electric baseboard heat and 1.6 times more energy efficient than air-source heat pumps. Geothermal networks are an additional 33 percent more efficient than individual GSHP systems because they share thermal energy among the various buildings in the network.

Figure 2. Average annual coefficient of performance for building heating and cooling systems



Source: GPI analysis based on data from "Thermal Energy Networks: Frequently Asked Questions," Building Decarbonization Coalition, accessed January 5, 2026.

Minnesota Project Examples

There are at least 87 GSHP systems that have been implemented by 50 Minnesota local and tribal governments, with some dating back to the late 1990s. Local government types that have implemented GSHP systems have included counties, schools, a regional organization, state colleges and universities, and an airport authority. Table 2 includes a selection of recent GSHP system projects that demonstrate a diversity of projects.

Table 2. A sampling of ground source heat pump systems in Minnesota

Project and year in service	Approximate cost*	Funding sources**	Building area and GSHP system description	Benefits
Eagan Eagan Art House recreation center 2025 (new construction)	$1.9 million (sum of two main contracts for GSHP system only)	Sustainability funding (franchise fees) Debt service (general obligation tax abatement bonds)	10,000 square feet (SF) Closed loop 40 vertical boreholes (200 ft deep)	$16,000 in energy savings annually 660 tons of CO_2 equivalent emissions avoided annually
Grand Marais City hall and liquor store 2024 (new construction)	$630,000 for GSHP system only (within an $8.5 million total cost for both buildings)	Federal tax credits General fund	11,000 SF Closed loop Nine vertical boreholes (360 ft deep)	Decarbonization of building heating and cooling
Maple Grove Ice arena*** 2025 (retrofit)	$1.8 million for GSHP system only	Federal tax credits	17,000 SF ice rink only Closed loop Two Darcy Solutions wells	18,000 kWh electricity saved annually
Rochester Geothermal network serving a library, civic center, theater, and art center 2025 (retrofit)	$25 million	Federal tax credits Congressionally directed spending General obligation bonds Custom utility rebates City budget Grants	750,000 SF Closed loop Five Darcy Solutions wells on a horizontal shared loop with back-up natural gas boilers	65% cost and 55% energy savings annually (compared to prior steam district) Resiliency as a network
St. Louis Park Westwood Hills Nature Center 2020 (new construction)	Data not available at publishing time	Data not available at publishing time	13,500 SF Closed loop 32 vertical boreholes (200–250 ft deep)	$6,750 in energy savings annually 90 tons CO_2 equivalent emissions avoided annually
St. Paul North End Community Center 2025 (new construction)	$350,000 for GSHP system only within a $30 million total building cost	Federal tax credits Congressionally directed spending Custom utility rebate Capital improvement budget and sales tax fund State bonding Grants	44 vertical boreholes (250 ft deep)	Buildings 2030 Standard

Source: Data from individual communications, web research, and workshop presentations (see Acknowledgments section).

Notes: *When GSHP systems are one part of an entire building project (new construction or retrofit), separating the costs for the GSHP system only can be challenging. Therefore, the data shown for costs are estimates. Costs for activities like permitting, engineering/design, electrical, and earthwork are shared among numerous project components.

**GSHP system-specific funding sources are challenging to separate from funding sources used for an entire project. Funding sources for entire projects are shown for most projects.

***See the *How is sustainability being considered for construction and renovations?* question about incorporating geothermal for the ice rink refrigeration.

Benefits of GSHP Systems

GSHP systems can provide multiple benefits to communities, including emissions reductions, energy savings, and system longevity and versatility.

Reduced Reliance on Fossil Fuels

A key benefit of GSHP systems is their potential to reduce a local or tribal government's reliance on fossil fuels for heating and cooling buildings. Fossil fuels, like natural gas, generate carbon emissions and contribute to climate change.

Transitioning from fossil fuel-sourced energy to geothermal energy is one way to *decarbonize* building operations. If heating loads for a building are fully met with energy-efficient electric heat pumps and the electricity to power those heat pumps is sourced from renewable energy, then the building is considered fully decarbonized or having carbon-free operation. However, any amount of integration of GSHPs into building operations will result in some decarbonization due to improved heating efficiency, regardless of the source of electricity.

An added benefit of heat pumps running on electricity is no indoor air pollutant exposure to building occupants, as there is no on-site combustion.[18]

Reduced Energy Use

With the high efficiency that GSHP systems offer for building heating and cooling, reduced energy use is a significant benefit. Compared to conventional heating and cooling systems, a GSHP system modestly increases electricity use and significantly decreases natural gas use.

Converting the units of electricity (kilowatt-hours) and natural gas (therms) to a common energy unit of kilo British thermal units (kBTUs) helps to clearly demonstrate net energy savings on most GSHP systems. GSHP systems can achieve energy savings of up to 75 percent compared with conventional heating and cooling systems.

Due to electricity prices being 5 to 6 times higher than natural gas, net energy savings do not always equate to operational cost savings. However, most GSHP systems aim to achieve cost savings, and many do, as shown in table 2.

Long Equipment Life

GSHP systems are built to last. The heat pump equipment itself has a long equipment life, in part because the wear and tear is reduced due to the mechanical equipment being located indoors. GSHP equipment may last as long as 30 years, compared to outdoor equipment such as rooftop units, air-source heat pumps, central air-conditioning, and single packaged systems, which have expected lifespans of 15–20 years.

There are two additional benefits to the equipment being located indoors: better adherence to a regular maintenance schedule and greatly improved maintenance worker comfort and safety.

Horizontal tubing and vertical U-loop pipes within boreholes of closed-loop ground heat exchangers can last 50 years or more, which illustrates the longevity of system components.[19] There are no known soils that degrade this tubing and piping material, and manufacturers typically provide a 50-year warranty.

Versatile Building Operation

Ground source heat pump systems add versatility and flexibility to building operations. GSHPs can transfer thermal energy between different mediums. For example, water-to-air heat pumps can supply building forced-air heating and cooling needs. Water-to-water heat pumps can supply radiant heating and cooling needs or domestic hot water. Heat pumps can also simultaneously heat and cool different parts of the same building.

Safeguard Water Resources

Water is top of mind for Minnesotans, and many local governments are responsible for supplying drinking water to their communities. The Minnesota Department of Health and the Minnesota Department of Natural Resources have regulations and permit processes pertaining to geothermal heating and cooling systems[20] to safeguard water resources from negative impacts. Namely, only certain heat transfer fluids are permitted, only Minnesota Department of Health-licensed contractors are allowed to construct geothermal boreholes and wells, and construction and water use permits are required.

All benefits described above apply to geothermal networks, with additional benefits arising from the scale of networked geothermal. These systems offer energy independence and reliability by using locally sourced thermal energy. Geothermal networks are a favorable load management strategy.

Geothermal networks contribute to clean energy workforce development. Workers trained in installing natural gas pipelines would bring the same skills to installing the horizontal shared piping system of a geothermal network and connecting buildings to the loop.

Geothermal networks also create an opportunity for equitable access to clean energy. All buildings adjacent to a geothermal network's horizontal loop would have the opportunity to join the network without incurring upfront system costs, and the network's effect on reduced operating expenses will benefit all connected to the system.[21]

Project Process

GSHP system projects can take time to develop, and several steps can be taken even before a project is proposed.

Pre-Project Stage

At any point, separate from a specific project, communities can commit to a decarbonized energy future through other planning processes and activities.

Many Minnesota communities that have implemented GSHP systems point to goals and directives in adopted policies, including climate action plans, energy action plans, comprehensive plans, municipal building decarbonization plans, development ordinances, and sustainable building policies. These commitments serve as a driving factor behind many communities' projects.

Local and tribal governments in Minnesota can learn from one another's experiences. A community considering GSHP systems for future new construction and building renovation projects can benefit by talking with other communities that have implemented projects.

Regardless of where a community is in the process of adopting GSHP systems, focusing on actions that lay the groundwork will make it easier to pursue ground source heat pump systems for new buildings and retrofits in the future.

While **geothermal networks** are generally considered an urban decarbonization solution, a strong case exists for this solution in rural Minnesota communities. Many growing rural cities are considering expanding their natural gas infrastructure to serve new planned developments.

These areas of rural communities are potential candidates for networked geothermal, especially when that development consists of a variety of building types in close proximity. A good variety of building types might include light industrial, commercial, small business, and multifamily—not just single-family residential.

Communities can convene stakeholders to familiarize them with building energy considerations and introduce them to geothermal networks without a specific upcoming project. The City of Rochester, Minnesota, found success with this approach. Stakeholders may include representatives from the following:

- Departments of facilities, public works, planning, finance, procurement, parks and recreation, real estate, and sustainability
- Offices of mayors, council members, and tribal leaders
- Committees on environment or sustainability
- Businesses and other institutions or organizations in the community
- Residential areas within the community
- Staff of other communities that have implemented geothermal networks

Project Planning Stage

When planning for GSHP systems, local and tribal governments should consider site selection, project team and stakeholder engagement, and funding identification.

SITE SELECTION

GSHP systems can be implemented during the construction of new buildings or as part of retrofits or major renovations to existing buildings. GSHP systems can help meet Minnesota's Sustainable Building 2030 (SB 2030) energy standards, which apply to new buildings or major renovations that receive state general obligation bonds.

For new building construction, incorporating a GSHP system during the design phase can maximize benefits, reduce project costs, and simplify implementation compared with adding it later in the project. The earlier GSHP systems are incorporated into a project, the better. Ground source heat pumps can be the most economical heating and cooling system for new buildings.

For retrofits, a screening of all public buildings can help prioritize sites where GSHP systems would be most appropriate by identifying buildings that have the following:

- High thermal loads
- Available adjacent land or parking lot
- Existing heating and cooling equipment that is nearing its expected end-of-life
- Other major building renovations or site work planned

Building energy benchmarking data can help compare the energy loads of multiple buildings. If the energy performance, or *energy use intensity*, has not already been determined for each major public building, calculating this metric would be the first step for a local or tribal government.

Energy use intensity or *EUI* (measured in kBTU per square foot) is calculated by converting the units of electricity (kilowatt-hours) and natural gas (therms) to kBTUs and then dividing by the building's conditioned area (square feet).

As for which public facility types are well-suited to GSHP systems, all buildings are generally good candidates, but those with heating and cooling needs are most suitable. Garages and shops are generally not a good fit due to frequent ventilation throughout the winter and typically no or little cooling in the summer. It is technically possible to accommodate the high intermittent heating loads of a garage with a radiant floor GSHP system, but without cooling, these projects are less financially viable.

Networked geothermal is well-suited to areas with high building density and a variety of building types. With buildings closer together, the whole system layout is more cost-effective due to the shared ambient-temperature loop serving more buildings with a shorter overall length.

As mentioned in the Overview section, having a variety of buildings results in some acting as sinks of heat, while others act as sources of heat. For example, in the winter, sinks of heat include homes, greenhouses, breweries, heated sidewalks, and domestic hot water in all building types, while sources of heat may be sewer water, refrigeration equipment in grocery stores and warehouses, ice rinks, and office buildings.

Many Minnesota communities have downtown districts served by steam systems. As those steam districts reach their end-of-life (some after 100 years of operation) or their capacity is no longer sufficient, converting the area served to networked geothermal is a viable option.

Similarly, as natural gas infrastructure ages, areas with concentrated issues or extensive repairs needed could be good candidates for a geothermal network. Neighborhoods planned for major reconstruction of existing infrastructure, such as water mains, sewers, or streets, also offer viable potential for networked geothermal areas. Pairing with other major projects is an opportunity to align planning, permitting, excavation, and other site work, potentially providing some cost savings.

Planning will include reviewing the entire community and using criteria to identify potential areas or neighborhoods for geothermal networks. HEET, a Massachusetts nonprofit organization furthering thermal networks, provides additional detail on possible criteria and further siting considerations beyond those mentioned above.

PROJECT TEAM AND STAKEHOLDER ENGAGEMENT

The project team responsible for leading GSHP system projects for local and tribal governments is typically jointly staffed by the following:

- Facilities or operations departments
- Sustainability, environment, or energy departments

Sustainability staff or other similar personnel may have primary roles in the pre-project and project planning stages, but facilities staff and similar personnel may play primary roles in the project implementation stage.

As a specific project advances, the project team will expand to include an engineering and design firm with expertise in GSHP system projects. Local and tribal governments can search for design and engineering firms in the IGSHPA Minnesota Business & Organization Directory, filter to Commercial Design, and look for those with experience working in Minnesota and experience working on projects similar to the potential sites.

Local governments will need to follow their own procurement policies, which may involve issuing a public request for proposals to select a design and engineering firm, rather than simply selecting a firm from the directory.

The project team will identify and convene stakeholders once a site has been selected. Stakeholders may include the following:

- Departments of public works, planning, and real estate to align with other relevant plans or projects
- Departments of finance and procurement to prepare for funding the project
- Key utility account managers to understand available programs
- State government staff working on funding or technical assistance programs that could support the project

Early contact with permitting staff from the Minnesota Pollution Control Agency and/or Minnesota Department of Natural Resources can be beneficial if sufficient detail is known at this stage. However, it is more likely that the project team and permitting agencies will have more to discuss and determine in the study phase of the project implementation stage.

The project team for **geothermal networks** is very likely to also include the following additional departments:

- Communications or public relations to lead community outreach
- Business development and support to involve non-public facilities

Other stakeholders for geothermal networks may include faith communities, neighborhood associations, residents, business associations, chambers of commerce, and other governmental or institutional entities located in the potential network area.

The project team should explore how and to what degree they plan to decarbonize a potential area to be served by a geothermal network. In other words, natural gas infrastructure will need to be considered when introducing a geothermal network to an area of existing buildings. It may remain in place to fuel secondary heating systems or to serve buildings that do not join the network.

In areas of a community where all new development is happening or where thermal energy infrastructure expansion is being considered, a geothermal network can be designed to meet all the buildings' heating and cooling needs.

FUNDING IDENTIFICATION

While a potential project is being considered, local and tribal governments can identify project funding and financing available in general and then assess which options exist for specific project types.

Refer to the Financing and Funding section of this document for explanations of many options available to local and tribal governments, including tax credits, state grants and loans, utility incentives, and performance contracting.

GREAT PLAINS INSTITUTE

Project Implementation Stage

From study to implementation, the development process for individual buildings or small-scale geothermal networks can take two to five years, depending on the size and complexity of the project. Figure 3 provides an overview of the phases involved in project implementation.

Figure 3. Project phases of implementing ground source heat pump systems

Source: GPI illustration derived from Salas O'Brien presentation during workshops (see Acknowledgments section).

Generally, smaller public facilities with GSHP systems align with the lower end of the time estimates shown in the graphic above, larger facilities fall in the middle, and small-scale geothermal networks fall at the upper end. Large-scale geothermal networks may require more time than the project process graphic outlines.

STUDY PHASE

During the study phase, the project goals are defined and then assessed for feasibility, constraints, and cost optimization.

A project's goals can be defined using key performance indicators, such as energy, energy use intensity, dollars, emissions avoided, or other metrics important to a local or tribal government. If the GSHP system is being added to an existing building, reference the building benchmarking data, if available, for a baseline of energy data. The information can then be used to understand the building's heating and cooling loads that need to be met by the GSHP system.

A technical feasibility study would include preliminary assessments of geologic survey data and other site-specific information. The soil types, the depth to bedrock, and the aquifer(s) subsurface positions would all factor into the technical feasibility of a proposed project. If possible, delaying thermal conductivity testing until the design phase (see sidebar) would allow project funds and effort during the study phase to be devoted to producing a more detailed analysis to better inform system design.

Site-specific constraints can be identified by engaging with the electric and natural gas utilities to check interconnection requirements and available incentives. Depending on the project's initial design concepts, the Minnesota Department of Health or the Minnesota Department of Natural Resources may need to be consulted to identify regulatory requirements, such as permits on the GSHP system interfacing with the ground, groundwater, or surface water.[22]

A lifecycle cost analysis can be useful during the study phase to explore what project elements may affect total project costs and system operating costs. It can also be used to optimize those elements for cost-effectiveness. With a specific site identified, funding and financing options can be detailed as part of this study phase.

At the end of a study phase, it should be clear whether the project is viable—technically, regulatorily, and financially—to proceed into the design phase.

DESIGN PHASE

During the design phase, results from a thermal response test are incorporated into thermal modeling. This modeling serves as the basis for determining design specifics, such as the type and layout of the ground heat exchanger, to meet the building's heating and cooling loads.

In both new construction and retrofit applications, Minnesota state code requires geothermal piping to be accessible, therefore, piping cannot be located beneath buildings.[23] When working with an existing building, the available space on-site may drive the system layout and the technology selected for the ground heat exchanger.

If a site has ample space, such as a large parking lot, green space, or sports field, closed-loop ground heat exchangers with horizontal piping or vertical boreholes arranged in a *borehole field* may be feasible.

If space is limited, the design may rely on closed-loop Darcy Solutions wells or an open-loop system to minimize the system's footprint relative to its thermal energy capacity.

In parallel with the technical design, a procurement strategy can be prepared by exploring potential drillers and design firms and deciding between energy savings performance contracting or traditional procurement. Local and tribal governments can also review existing RFPs by other communities that have implemented GSHP systems to gain familiarity ahead of the bid phase.

With the known design parameters, detailed site plans are drawn, and specifications are defined for use in project bidding.

At some point during the project development process, a **test borehole** will need to be drilled on-site to perform a thermal response test, also referred to as thermal conductivity testing, to confirm the desktop review of the site's geology.

For open-loop systems, a test borehole is essential during the **study phase**. For closed-loop systems, this can occur in the early stages of the **design phase**, especially if the proposed project seems technically, regulatorily, and financially feasible for a GSHP system.

A test borehole not only provides soil thermal properties to inform the design and sizing of the system, but also provides constructability information that is useful in the bid phase. Including drilling depth, ground conditions, and site-specific geology in a request for proposal (RFP) results in more consistent and competitive bids.

As a project cost-saving measure, it is possible for the test borehole to be repurposed as a permanent borehole. However, to do so, some understanding of how the system will be situated on the site is needed.

Small horizontal closed-loop systems with a capacity of 30 tons or less do not typically require thermal conductivity testing; site-specific soil information is usually sufficient. Larger horizontal closed-loop systems will benefit from a test borehole, similar to vertical systems.

BID PHASE

The bid and construction phases for GSHP systems are similar to processes for any other capital investment project carried out by local governments.

The typical bidding activities of soliciting contractor bids, evaluating proposals, and awarding contracts apply to GSHP system projects. The duration of the bid phase is influenced by whether the process will be public, invitation-only, or private, as public bidding processes typically last longer than those that are private or invitation-only. For invitation-only and private bidding processes, local and tribal governments can refer to the IGSHPA Minnesota Business & Organization Directory.

An often overlooked item to include in the RFP is commissioning and/or measurement and verification (M&V) of a GSHP system once it is operational. Incorporating such requirements in the RFP is a way to ensure the system operates as designed and to make corrections if it does not.

CONSTRUCTION PHASE

The typical construction tasks also apply to GSHP systems. These tasks include carrying out the system build, managing the budget and schedule, and overseeing quality control to ensure that what is installed matches the specifications.

If GSHP infrastructure is the only focus of a project, construction is expected to last about a year. If the project involves constructing a new building with a GSHP system included, construction can be expected to last more than a year.

If a geothermal network is being implemented among existing buildings, construction can last for more than two years. This would include installing new heat pump equipment and building out shared infrastructure of vertical boreholes and a horizontal piping system.

OPERATION AND MAINTENANCE PHASE

The operation and maintenance phase is important for keeping equipment in good working order, monitoring performance, and making adjustments as needed.

The main mechanical equipment of GSHP systems requiring maintenance are water pumps, which are a dependable and well-known technology. With closed-loop Darcy Solutions wells, the submerged pump and heat exchanger may need to be pulled every 10–15 years for maintenance, so the site must be accessible to large trucks at each wellhead.

Open-loop systems would have a similar maintenance schedule, as their production wells will have in-well pumps like any other water well. If pump fouling is anticipated due to poor water quality, pulling pumps (and in-well heat exchange equipment) may need to occur more frequently.

The heat transfer fluid-pumping equipment in closed-loop vertical borehole and closed-loop horizontal piping systems is likely to be above grade, and therefore is easier to access and provide regular maintenance.

The heat pump equipment within the building needs regular maintenance, similar to that of other heating and cooling equipment, which typically involves changing filters. In-house local government staff handles this maintenance. The heat pump refrigeration systems are sealed and, therefore, require no regular maintenance. If a repair of the refrigeration components is needed, then an outside contractor would be hired to perform this work.

Monitoring a GSHP system is critical to ensuring the system performs as expected based on thermal modeling. A suitable performance metric is energy use intensity, measured in kBTU per square foot. See the Reduced Energy Use and Site Selection sections in this guide for detailed explanations of how to determine energy use intensity. If a building consistently uses more energy than anticipated, system recommissioning may be needed to identify where to make adjustments.

To support shared learning across projects, local and tribal governments may choose to contribute their GSHP systems data to any of the following open-source data collection systems:

- Geothermal Project National Environmental Policy Act (NEPA) Database
- Geothermal Data Repository and Geothermal Data Repository Data Lake from the US Department of Energy Geothermal Technologies Office
- HEET Geothermal Network Databank (for networks only, not individual GSHP systems)

Financing and Funding

A GSHP system, including an underground heat exchanger system and indoor heating and cooling heat pump equipment, can cost up to 50 percent more than conventional heating and cooling systems.

For retrofit projects, capital costs are more favorable if other site work is planned (e.g., parking lot reconstruction). For new public facilities, ground source heat pumps can be the most cost-effective heating and cooling system when assessed over the life of the building and equipment.

Fortunately, there are several options for helping reduce the costs of GSHP systems—both during the pre-development and construction phases for retrofit and new construction projects. Local governments have used traditional funding mechanisms (e.g., general fund, capital improvement budgets) and other mechanisms (e.g., energy savings performance contracts, grants, tax credits) to pay for GSHP systems as part of building construction or renovation projects.

Utility Programs

Minnesota electric utilities offer programs that can help local and tribal governments pay for feasibility studies and project design, such as energy design assistance programs and engineering study rebates. Utilities also offer rebates that may help cover the cost of GSHP system equipment. Utility key account managers can help local governments navigate utility offerings.

In addition, under Minnesota's Natural Gas Innovation Act, gas utilities are required to submit innovation plans that include pilot projects to explore technologies that can reduce emissions and natural gas consumption, including thermal energy networks.[24]

Interested communities should follow these pilot projects to see if they offer opportunities to help local governments fund geothermal projects or allow local governments to participate.

MINNESOTA EXAMPLES

The City of Woodbury participated "in Xcel Energy's Energy Design Assistance Program during the initial planning phase of the M Health Fairview Sports Center. The project received $200,000 in rebates from Xcel Energy, offsetting the costs of its GSHP system.

The City of Saint Paul leveraged Xcel Energy's Engineering Study Rebate program[25] to pay for the cost of a geothermal feasibility study for a parks and recreation department operations building. The City also used Xcel Energy's Energy Efficient Buildings program to identify applicable rebates for planned energy measures—including GSHP system components—at the Hamline Library site.

State Grants

State grants can help offset the cost of planning for potential geothermal systems. In 2025, the Minnesota Department of Commerce launched the Geothermal Planning Grant Program, which offers grants of up to $150,000 for activities related to planning a GSHP system that heats and cools one or more buildings. The Minnesota Pollution Control Agency Local Climate Action Grant program has also been used to fund studies and other planning activities. The availability of future funding through both grant programs will depend on whether the state legislature decides to continue funding the programs.

MINNESOTA EXAMPLES

Eight Minnesota entities received Department of Commerce geothermal planning grants in 2025 to assess the feasibility of GSHP systems in a variety of buildings and campuses. The grants support activities ranging from modeling the building's heating and cooling needs to understanding whether geological conditions would support a GSHP system through test borehole drilling.

The City of Robbinsdale used a $20,000 Minnesota Pollution Control Agency Local Climate Action Grant to fund a study to "determine the economic and geologic feasibility" of a GSHP system for a planned public works building.[26]

Federal Grants and Technical Assistance

The US Department of Energy has offered grants to support geothermal projects in the past through its Geothermal Technology Office and may offer grants again in the future.

In addition to grants, the National Laboratory of the Rockies (formerly National Renewable Energy Laboratory) offers 40–60 hours of free technical assistance to local governments through its Energy to Communities (E2C) Expert Match program. Through this program, national lab experts may be able to help communities determine if a GSHP system is a good fit for a given project.

MINNESOTA EXAMPLE

In 2023, the City of Duluth received a $700,000 **Community Geothermal Heating and Cooling Design and Deployment** grant from the US Department of Energy to explore creating a new geo-exchange district energy system in Lincoln Park and connecting waste heat from the Western Lake Superior Sanitary District into Duluth's existing district energy system.[27]

Energy Savings Performance Contracts

Energy savings performance contracts (ESPCs) are a common tool for Minnesota local and tribal governments making energy efficiency improvements. Under an ESPC, an energy services company (ESCO) designs, installs, and maintains energy efficiency and renewable energy measures. The ESCO guarantees the system's performance. The government entity pays for the project through realized energy savings, and projects are set up to be cash-flow positive.

Federal Tax Credits

Multiple Minnesota communities have recouped (or plan to recoup) part of the cost of their GSHP system projects thanks to the federal Section 48 ground source heat pump tax credit. This credit applies to "equipment which uses the ground or ground water as thermal energy source to heat a structure or as a thermal energy sink to cool a structure."[28]

Local governments and other tax-exempt entities can take advantage of this and other clean energy tax credits through a mechanism called elective pay (also known as direct pay). The ground source heat pump tax base credit is currently 6 percent, but the value increases to 30 percent if the project has a nameplate capacity of less than 1 megawatt or about 284 tons.[29] Projects larger than 1 megawatt must meet prevailing wage requirements to achieve the 30 percent credit.

Projects can get bonus credits for using components manufactured in the US and for being located in an energy community.[30] The tax credit is set to expire on January 1, 2035. However, the base credit decreases to 5.2 percent on January 1, 2033, and to 4.4 percent on January 1, 2034, if construction starts during calendar years 2033 and 2034, respectively.[31]

MINNESOTA EXAMPLE

The Metropolitan Council received a payment for approximately $2 million from the Internal Revenue Service that helped cover the cost of their **North Loop Bus Garage project**, which included GSHP heating and cooling infrastructure.

Minnesota Climate Innovation Finance Authority

The Minnesota Climate Innovation Finance Authority (MnCIFA) offers flexible financing for innovative clean energy projects like GSHP systems. MnCIFA can provide bridge loans to help local governments and other tax-exempt entities develop projects that are eligible for clean energy tax credits—loans that are repaid once the entity receives payment from the IRS.[32] See MnCIFA's Steps to apply page for information about the pre-application process.

MINNESOTA EXAMPLE

MnCIFA has provided financing for several geothermal projects, including a $4.7 million bridge loan for **The Heights** geothermal district energy system and a $4.5 million bridge loan for a GSHP system at the **Avenues for Youth** housing and shelter facility.

Conclusion

GSHP systems offer an opportunity for local and tribal governments to work toward their climate goals with a reliable, highly efficient technology that electrifies some of a community's building heating and cooling needs.

This guide provided information on ground source heat pump systems to help local governments evaluate and implement GSHP systems in their public facilities.

The guide offered a technological overview, benefits and impacts, project process considerations, and financing and funding mechanisms. Minnesota-specific project examples, guidance, and programs presented in this guide demonstrate that GSHP systems are not only possible but also prudent in Minnesota.

Geothermal networks were also introduced in this guide to inspire Minnesota local governments to explore an even more energy-efficient way to heat and cool buildings. Unlike stand-alone GSHP systems, these networks share thermal energy among connected buildings. The potential for energy independence and equitable access to clean energy is also a compelling aspect of geothermal networks.

GREAT PLAINS INSTITUTE

Endnotes

1 "Geothermal Energy Fact Sheet," US Department of Energy, February 16, 2023.

2 "Links," International Ground Source Heat Pump Association, accessed January 16, 2026.

3 "How Does it Work?," Minnesota Geothermal Heat Pump Association, accessed January 5, 2026.

4 "Geothermal Heat Pumps," US Department of Energy, accessed January 5, 2026.

5 "Thermal Energy Networks: Frequently Asked Questions," Building Decarbonization Coalition, accessed January 5, 2026.

6 "Geothermal Loop Options," Minnesota Geothermal Heat Pump Association, accessed January 5, 2026; International Ground Source Heat Pump Association, Acronyms and Terminology: GSHP Industry Training Series (International Ground Source Heat Pump Association, April 2025).

7 "Geothermal Heating and Cooling Systems," Minnesota Department of Health, last updated October 18, 2024.

8 "The Geothermal Ecosystem," International Ground Source Heat Pump Association, accessed January 5, 2026.

9 "Geothermal Loop Options."

10 "Geothermal Loop Options."

11 "Geothermal Everywhere," Darcy Solutions, accessed January 5, 2026.

12 "Geothermal Pilot Reference Guide," Eversource, accessed January 5, 2026.

13 "Thermal Energy Networks (TENs)," Building Decarbonization Coalition, accessed January 5, 2026.

14 "Thermal Energy Networks (TENs) Terminology," Building Decarbonization Coalition, accessed January 5, 2026.

15 "The Geothermal Ecosystem."

16 "Thermal Energy Networks: Frequently Asked Questions."

17 "Thermal Energy Networks: Frequently Asked Questions."

18 "Thermal Energy Networks (TENs)."

19 "The Geothermal Ecosystem."

20 "Geothermal Heating and Cooling Systems."

21 "Thermal Energy Networks (TENs)."

22 "Geothermal Heating and Cooling Systems."

23 Minn. R. 4725.7050, subpt. 7.

24 "Natural Gas Innovation Act (NGIA)," Minnesota Public Utilities Commission, accessed January 6, 2026.

25 For updated information, see "Business Savings," Xcel Energy, accessed January 6, 2026.

26 "Climate Grants," Minnesota Pollution Control Agency, accessed January 5, 2026.

27 "Community Geothermal," City of Duluth, accessed January 5, 2026.

28 Lawyers for Good Government, *L4GG Guidance Brief: Section 48 Credit for Ground-Source Heat Pumps* (Lawyers for Good Government, November 26, 2025).

29 Jowan Abouhosah, Jiyoon Choi, Beckett Woodworth, Robert Moczulewski, "Final regulations released for the section 48 tax credit," Baker Tilly, December 9, 2024.

30 "L4GG Guidance Brief."

31 Lawyers for Good Government, *Elective Pay Blueprints* (Lawyers for Good Government, April 2025) 5.

32 Minnesota Climate Innovation Finance Authority, *2025–2026 Strategic Plan* (Minnesota Climate Innovation Finance Authority, accessed January 5, 2026).