

A CESA Technology
Innovation White Paper

What States Need to Know about Networked Geothermal



ABOUT THIS REPORT

This paper was produced by the Clean Energy States Alliance (CESA) in response to requests from CESA Member states for information about networked geothermal. The paper seeks to present clear, plain-English information about the topic for state energy agencies, their legislative counterparts, and other stakeholders.

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Cover image: Installation of the geothermal manifold as part of the Denver Westwood Recreation Center project. Credit: Shannon Bauman, Colorado Energy Office.

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Contents

Introduction	4
What is networked geothermal?.....	4
What problems does networked geothermal solve?	5
What does a networked geothermal system look like?.....	7
Where does networked geothermal make the most sense?.....	9
How much does networked geothermal cost?.....	10
Who owns and operates networked geothermal systems?.....	10
What role can utilities play?	11
What policy and regulatory issues do states need to understand?	12
How can states support early projects and pilots?	12
How can networked geothermal advance equity and affordability goals?	14
What workforce considerations should states be aware of?	14
Do geothermal networks qualify for federal tax credits?.....	15
Conclusion.....	16
Additional resources.....	17
Endnotes	19

Introduction

Networked geothermal—also referred to as “ambient loop systems,” “community geothermal,” or “fifth generation district heating & cooling,” among other terms — is gaining attention among states, utilities, and local governments across the United States. Several gas utilities are piloting projects; many states—including Colorado, Massachusetts, Minnesota, and New York—have authorized or required pilot programs, and federal funding has supported early demonstrations.^{1, 2}

Networked geothermal raises new policy, regulatory, financing, and equity questions. This paper presents plain-English answers to foundational questions about networked geothermal. It is intended to support early understanding and decision-making for members of the Clean Energy States Alliance (CESA) and other state officials. It does not provide engineering specifications or legal advice. Rather, it outlines what is known, what remains uncertain, and what questions states may wish to consider.

What is networked geothermal?

Networked geothermal is one form of a broader category of systems known as thermal energy networks (TENs). TENs use shared infrastructure to move heat between buildings and local thermal energy sources. These sources can include the ground (via boreholes), wastewater systems, surface water, or waste heat from buildings, data centers, or industrial processes.

Networked geothermal refers specifically to TENs that use the ground—typically through distributed borefields or ground heat exchangers—as a primary thermal energy source and sink. In these systems, multiple buildings are connected through a shared loop that exchanges heat with the earth, often using ambient-temperature distribution.

At its core, the system consists of:

- A network of underground pipes filled with water or a water-antifreeze solution
- Boreholes or trenches that exchange heat with the earth (and in some systems, additional thermal sources such as wastewater, surface water, or waste heat from buildings or industrial processes)
- Heat pumps inside each connected building

Unlike traditional ground-source heat pumps, which serve a single building with dedicated boreholes, networked geothermal shares the underground infrastructure across multiple buildings. This shared system can improve efficiency by allowing heating and cooling loads to balance across buildings.



*Geothermal pipe coils at the bottom of a trench.
Credit: BanksPhotos/iStock.*

Networked geothermal differs from conventional district energy systems in that it typically operates at ambient or near-ambient temperatures, rather than distributing steam or high-temperature hot water from a central plant. Each building uses its own heat pump to raise or lower temperatures as needed.³

What problems does networked geothermal solve?

Decarbonizing heating and cooling

Space and water heating account for a significant portion of building-sector emissions in most states.⁴ Electrification through heat pumps is a key strategy for reducing these emissions.

Networked geothermal systems provide heating and cooling using electrically powered heat pumps that exchange heat with the ground rather than burning fossil fuels. Because these systems do not rely on on-site combustion, they can significantly reduce direct emissions from buildings. When paired with increasingly clean electric grids, geothermal heat pump systems can provide low-carbon heating and cooling over time.⁵

By enabling multiple buildings to share underground thermal infrastructure, networked geothermal can also make ground-source heating and cooling accessible in places where individual building systems may be difficult or expensive to install.⁶

Reducing peak demand

Because underground temperatures are relatively stable year-round, ground-source systems can reduce peak winter electric demand compared to air-source heat pumps. They can also reduce cooling loads in hot climates compared to conventional air conditioning systems, due to higher system efficiency, and decrease the load compared to air conditioning. In cold climates, this may mitigate strain on electric systems during extreme weather events. In fact, geothermal networks are the most efficient technology available for heating and cooling homes; installing them at scale will flatten peak demand and decrease the amount of the electric buildout.⁷

Resilience

Networked geothermal infrastructure is largely underground and modular. While heat pumps still require electricity, the absence of on-site fuel combustion and the distributed nature of the system may enhance resilience compared to centralized fossil-fuel heating systems.

Cost stability

Geothermal systems eliminate exposure to fuel price volatility. Although electricity prices vary, the long-lasting underground infrastructure (50 years or more) can provide relatively stable heating costs over decades.⁸

Economic development

Installation of borefields and piping requires skilled labor, including drilling, trenching, and pipe installation. These activities overlap with gas utility workforce skills, presenting workforce transition opportunities for individuals and communities during a transition away from gas infrastructure.⁹

What does a networked geothermal system look like?

Figure 1. Example of a networked geothermal system.

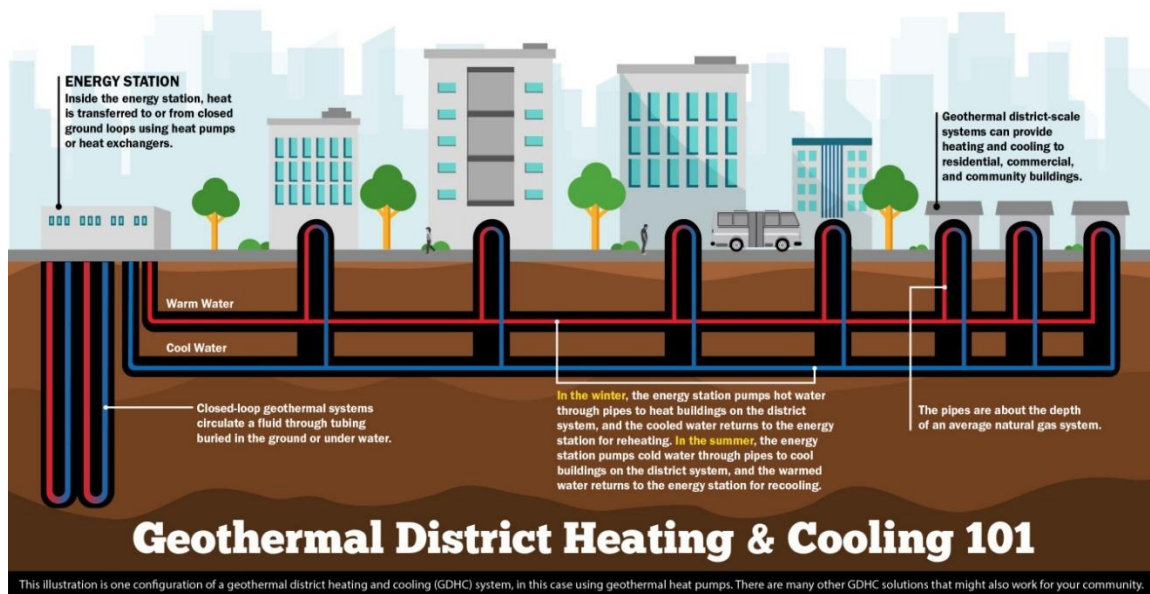


*In a networked geothermal system, multiple buildings are connected through a shared underground loop that exchanges heat with the ground. Each building uses its own heat pumps to provide heating and cooling.
Source: Home Energy Efficiency Team (HEET), "Definition of Geothermal Networks."*

A typical networked geothermal system includes:

1. **Borefield or trench network** – vertical or horizontal loops exchange heat with the ground
2. **Distribution piping** – a closed-loop pipe network connects multiple buildings
3. **Energy transfer stations** – interface points between the loop and buildings
4. **Building-level heat pumps** – provide heating and cooling inside structures

Figure 2. Components of a geothermal district heating and cooling system.



This image shows the primary components of a geothermal district heating and cooling system: an energy station and underground pipes connecting multiple buildings within a shared system. Traditional geothermal district energy systems often include a central energy plant that distributes heating and cooling through a pipe network. In contrast, networked geothermal (ambient loop) systems rely primarily on distributed ground-source heat pumps in connected buildings, though they may still include central equipment for circulation and system balancing. Source: U.S. Department of Energy.

Many systems operate as “ambient temperature loops”, circulating water between 50°F and 80°F, but sometimes across broader ranges depending on system design. Buildings exchange heat with the loop, and the loop exchanges heat with the ground as needed.¹⁰ Although this is the most common model for modern geothermal networks, other configurations exist. Some systems operate as low-temperature district systems, where the network distributes slightly warmer water and building-level heat pumps require less temperature lift. Others use a central-plant model, where heat is extracted from the ground or another source at a central facility and distributed to buildings at higher temperatures, often without requiring heat pumps in each building. Systems can range from campus-scale to neighborhood installations involving dozens or hundreds of buildings.

Although there are still relatively few completed networked geothermal systems in the US, a growing number of projects are underway or in operation. For example, Framingham, Massachusetts is home to one of the first utility-led geothermal network pilots, developed by Eversource Energy, which connects multiple buildings through a shared ground loop.¹¹ It includes 140 retrofitted buildings, and an upcoming expansion will double the network’s size. In Ithaca, New York, Cornell University is advancing a large-scale, networked geothermal “Earth Source Heat”

system that will use deep geothermal wells to provide district heating and cooling to campus buildings.¹² Carbondale, Colorado is advancing a community-scale networked geothermal system serving affordable housing and civic buildings, with on-site drilling and system testing already completed as part of a U.S. Department of Energy–supported project.¹³ These and other early projects are helping to inform system design, cost, and regulatory approaches for broader deployment.

Where does networked geothermal make the most sense?

Networked geothermal is not well suited to all locations. It may be most cost-effective in:

- New developments where trenching can be coordinated with construction
- Campuses (universities, hospitals, schools)
- Dense neighborhoods with diverse heating and cooling loads
- Areas facing gas infrastructure replacement
- Facilities with non-borehole thermal sources such as data centers, wastewater treatment facilities, or ice rinks

Urban density can improve economics by reducing pipe length per building, but siting borefields in dense urban cores can present challenges. Suburban settings may offer more land flexibility. However, urban environments provide many other sources of thermal energy, such as wastewater sewer recovery or waste heat from a data center or other cooling dominant building, as noted above.

Geological conditions and groundwater regulations influence feasibility.¹⁴ Site-specific feasibility studies remain essential.



Bedrock Energy CEO Joselyn Lai, wearing a safety vest, gestures while explaining thermal energy network design to Colorado Governor Jared Polis. They stand beside an earthen trench at the construction site of the Town of Hayden Northwest Colorado Business Park Geothermal Project, with the Hayden Coal-Fired Power Plant and rolling hills in the background. Credit: Bryce Carter, Colorado Energy Office.

How much does networked geothermal cost?

Costs vary widely depending on geology, scale, density, labor, and regulatory context. Upfront capital costs are typically higher than for conventional heating and cooling systems because networked geothermal includes underground infrastructure providing the generation and the distribution of thermal energy on site. However, ground loops can last 50 years or more, significantly longer than most building HVAC equipment.¹⁵

Lifecycle cost comparisons remain limited due to the early stage of deployment. Overall, ground source heat pumps last significantly longer than air source heat pumps due to absence of outdoor components and lower environmental degradation.¹⁶ The front-of-meter infrastructure is typically guaranteed to last decades. Several pilot projects suggest long-term cost competitiveness when fuel price volatility and avoided gas infrastructure investments are considered.¹⁷ Costs are expected to decline as experience with geothermal networks increases.

Cost recovery approaches include:

- Utility rate-basing
- Special assessment districts
- Service subscription fees
- Campus capital financing
- Federal investment tax credits of 30-50% for projects using prevailing wage and apprentices

More data from pilot projects will be necessary to determine typical cost ranges.

Who owns and operates networked geothermal systems?

Ownership models include:

- Utilities (gas and/or electric), including municipal or community-owned systems
- Campus-owned systems
- Public-private partnerships

Ownership structure influences financing, risk allocation, and regulatory oversight. Several states, including Colorado, Minnesota, and New York, have passed state climate legislation that allows or requires utilities to pilot networked geothermal systems.¹⁸

What role can utilities play?

Utilities may:

- Plan and build thermal networks
- Integrate geothermal into long-term gas transition planning
- Finance infrastructure through regulated rates
- Provide customer service and billing

For example, utilities in states such as Massachusetts and New York are piloting geothermal network projects as part of broader strategies to transition gas infrastructure and meet climate goals.

Some regulators are evaluating networked geothermal as potential “non-pipeline alternatives” where gas infrastructure would otherwise require replacement.¹⁹

Other key questions include cost allocation, consumer protections, and regulatory classification (i.e., how the system is legally categorized within state utility law, which determines which regulator oversees it and which rules apply).



Borehole drilling for a networked geothermal project in Framingham, MA. Credit: Eversource Energy.

What policy and regulatory issues do states need to understand?

Networked geothermal raises several regulatory questions:

- Should thermal networks be regulated like gas or electric utilities?
- How should rates be structured?
- What consumer protections apply?
- How are costs allocated between participants and non-participants?

Because these systems do not fit neatly into existing utility frameworks, statutory clarification may be required.

A key regulatory issue is utilities' "obligation to serve"—the legal requirement that gas utilities provide service to customers in their territory. Networked geothermal and other thermal energy networks challenge this framework by offering a pathway to replace gas service altogether.

For example, California's SB 1221 establishes neighborhood-scale decarbonization pilots and allows utilities to be relieved of their obligation to provide gas service in a project area if adequate replacement energy service is available. The law also allows projects to proceed if a supermajority (approximately two-thirds) of affected customers or property owners agree, helping address the challenge of customer consent in network-scale transitions.²⁰

How can states support early projects and pilots?

State energy agencies can play an important role in supporting early exploration and deployment of networked geothermal systems. One of the most common early steps is to fund feasibility and planning studies, which can take several forms.

States may support statewide or regional assessments that evaluate where geothermal networks could be most viable. These studies can analyze factors such as building density, heating demand, geology, and existing energy infrastructure. Some analyses also identify locations where aging gas pipelines may need replacement, which could present opportunities to consider thermal networks as alternatives.²¹

States can also fund site-specific feasibility studies that evaluate whether a particular neighborhood, campus, or building cluster is suitable for a geothermal

network. These studies typically assess local geology, building heating and cooling loads, infrastructure layout, and estimated project costs.

In some cases, state energy agencies conduct these analyses themselves or through consultants. In other cases, states provide grants to municipalities, utilities, housing authorities, or community organizations to conduct feasibility studies for potential projects in their jurisdictions.

These studies help communities and policymakers better understand where networked geothermal may be technically and economically viable before committing to project development.

Beyond feasibility studies, states may also support early projects by:

- Providing grants or low-interest financing for pilot installations
- Convening utilities, municipalities, and developers
- Incorporating geothermal networks into broader building decarbonization strategies
- Supporting data collection from pilot projects to inform future policy decisions
- Leading by example through installation of geothermal networks at state-owned facilities



A geothermal pipeline is installed beneath a road in Framingham, MA. Credit: Eversource Energy.

How can networked geothermal advance equity and affordability goals?

States may incorporate geothermal into affordable housing developments, target high energy burden communities, and ensure transparent pricing structures.

If a network is utility-owned, regulators must consider cost allocation impacts on non-participating customers. Equity outcomes will depend heavily on program design.

What workforce considerations should states be aware of?

Networked geothermal requires drilling contractors, pipefitters, HVAC technicians, and engineers. Workforce analyses suggest potential overlap with existing gas utility workforce skills, creating reskilling opportunities.²² States may consider training programs and certification pathways. Examples include:

- Geothermal heat pump installer training programs, often offered through community colleges, technical schools, or industry organizations.
- Drilling and ground heat exchanger installation training, which prepares workers to install borefields and underground piping.
- Continuing education and certification programs such as those offered by the International Ground Source Heat Pump Association (IGSHPA) and the Geothermal Exchange Organization (GEO) for designers, installers, and inspectors.
- Apprenticeship and workforce transition programs that help gas utility workers and HVAC technicians gain skills relevant to geothermal and heat pump systems.



Utility pipefitters on the job in Framingham, Massachusetts. Credit: Eversource Energy.

Do geothermal networks qualify for federal tax credits?

Often, yes. But eligibility depends on who owns the system, how it is structured, and which parts of the system qualify as eligible ‘energy property’ under federal tax law.

Components that are commonly considered eligible include ground-source heat pumps installed in buildings and ground heat exchangers, such as boreholes and loop fields that exchange heat with the earth. Eligibility may be less clear for other parts of a networked geothermal system, such as shared underground distribution piping that connects multiple buildings, energy transfer stations or interconnection equipment, and monitoring or control systems.²³

Several Inflation Reduction Act (IRA) provisions may apply to networked geothermal projects, including:

- Section 48 (Investment Tax Credit, or ITC)
- Section 45L (Energy Efficient Home Credit); set to expire in June 2026
- Section 6417 (Direct Pay / Elective Pay)

Ground-source heat pumps installed in homes have historically qualified for the Residential Clean Energy Credit under Internal Revenue Code §25D. However, recent federal legislation has significantly altered or eliminated this credit, and eligibility for residential geothermal incentives may be limited or no longer available depending on current law.²⁴ State agencies and project developers should consult the most up-to-date IRS and Treasury guidance when evaluating eligibility, as federal tax policy in this area continues to evolve.

Building-level heat pumps

Commercial and multifamily building systems generally qualify under the Investment Tax Credit (ITC) in IRC §48. This portion of eligibility is well established. The base credit is 6%, increasing to 30% if prevailing wage and apprenticeship requirements are met. Bonus credits may apply for domestic content or energy community siting.

Shared loop infrastructure

A more complex question is whether shared underground loop fields and distribution piping qualify when serving multiple buildings. Section 48 includes equipment that “uses the ground or ground water as a thermal energy source” for heating or cooling. Boreholes and loop fields are generally understood to qualify

when tied to a building-level system. However, existing IRS guidance addressing geothermal heat pump eligibility under Sections 25D has primarily focused on property installed to serve individual buildings and does not specifically address multi-building ambient thermal networks.²⁵

Utilities and public entities

Investor-owned utilities may claim the ITC for qualifying property under §48, subject to normalization and regulatory cost-recovery rules. Public entities (including municipalities, school districts, and state agencies) may use “direct pay” under §6417 to receive a Treasury payment equal to the value of certain credits.²⁶ This provision is especially important for publicly owned geothermal networks.

Conclusion

Networked geothermal represents a promising, but still emerging, approach to decarbonizing heating and cooling at scale. By leveraging shared infrastructure and the thermal properties of the ground, these systems can reduce emissions, improve energy efficiency, and provide long-term cost stability. At the same time, they raise important questions around cost, ownership, regulation, and equity that states are only beginning to address. Early pilot projects and policy efforts are helping to build a clearer understanding of where and how these systems can succeed. For state energy agencies, the near-term opportunity is to support continued learning—through feasibility studies, pilot programs, and stakeholder engagement—while laying the groundwork for regulatory and market structures that can enable broader deployment over time.

Additional resources

[Definition of Geothermal Networks](#) (Home Energy Efficiency Team, 2023)

Webpage. Provides a clear, accessible overview of what geothermal (thermal energy) networks are and how they function at a community scale.

[Geothermal Energy Networks Data Bank](#) (Home Energy Efficiency Team, 2024)

Dataset/mapping tool. Provides data and mapping of existing and planned geothermal network projects, including key characteristics and development status.

[A Definitional Taxonomy for \(Geo\)Thermal Energy Networks](#) (Home Energy Efficiency Team, 2024)

Report. Presents a structured framework for categorizing different types of thermal energy networks and clarifying terminology across the field.

[Geothermal Drilling Centers of Excellence](#) (Geothermal Market Capacity Coalition, 2024)

Report. Examines workforce and infrastructure needs for scaling geothermal deployment, with a focus on expanding drilling capacity and training.

[Thermal Energy Networks \(TENs\) FAQ](#) (Building Decarbonization Coalition, 2024)

Webpage. Answers common questions about thermal energy networks, including how they work, their benefits, and key policy considerations.

[Thermal Energy Networks Legislative Guidebook](#) (Building Decarbonization Coalition, 2025)

Guidebook/report. Provides guidance for policymakers on designing legislation to support thermal energy networks, including examples from leading states.

[How to Develop a Thermal Energy Network Toolkit](#) (Vermont Community Thermal Networks, 2024)

Toolkit. Offers practical, step-by-step guidance for communities and developers on planning and implementing thermal energy network projects.

[U.S. Geothermal District Heating Systems and Funding Data](#) (U.S. Department of Energy, 2020)

Dataset. Compiles data on geothermal district heating systems in the United States, including project characteristics and funding sources.

Additional resources (cont.)

[Geothermal Networks: An Opportunity for States](#) (Clean Energy States Alliance, 2023)

Webinar. Summarizes key considerations for state energy agencies exploring geothermal networks, including policy, financing, and deployment strategies.

[Networked Geothermal Systems](#) (Massachusetts Clean Energy Center, 2023)

Video. Provides an overview of how networked geothermal systems work and highlights real-world applications and benefits.

[Understanding Networked Geothermal Technology](#) (Eversource Energy, 2023)

Video. Explains the basics of networked geothermal systems and how utilities are deploying pilot projects to serve multiple buildings.

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Row 1 (L-R): CESA; Resonant Energy; CESA; Bigstockphoto/DavidM199. Row 2 (L-R): Portland General Electric; CESA; Murray Carpenter/Maine Public. Row 3 (L-R): Orsted (US Offshore Wind); CESA; Solara/California Energy Commission; iStockphoto/Fotomax. Row 4 (L-R): Tom Piorkowski; CESA; Shutterstock/Soonthorn Wongsaita

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ABOUT CESA

The Clean Energy States Alliance (CESA) is a national, nonprofit coalition of public agencies and organizations working together to advance clean energy. CESA members—mostly state agencies—include many of the most innovative, successful, and influential public funders of clean energy initiatives in the country. CESA works with state leaders, federal agencies, and other stakeholders to develop and promote clean energy programs and markets, with an emphasis on renewable energy, energy equity, financing strategies, and economic development. CESA facilitates information-sharing, provides technical assistance, coordinates multi-state collaborative projects, and communicates the views and achievements of its members.



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