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Seeking Balance: The Path Forward for Thermal Energy Network Regulation

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Executive Summary

The individual components of thermal energy networks — thermal energy resources distributed in the community, a network of underground water pipes in the streets and customer heat pumps connected to that network — are all proven technologies, yet they combine to form a novel shared energy service that is just getting underway. At the time of publication, one utility pilot serves 135 customers in Massachusetts with several others planned in New York, Minnesota and Colorado. Thermal energy networks are attracting growing attention as a reliable, resilient, efficient, safe, local and clean solution for building heating and cooling. One potential benefit is significantly reducing winter peak electricity usage in cold climates, particularly compared to other electric heating options, such as electric resistance heating and air-source heat pumps.

Balance is a theme across two different aspects of this report: (1) the operation of a thermal energy network and the management of temperature, or thermal energy, across the system; and (2) the evolution of regulatory approaches from initial pilots to a full regulatory scheme. First, thermal energy balance, the management of heat sources and sinks to maximize efficiency of customer equipment operation, is the key design and operating criterion for thermal energy networks. Second, to build and deploy thermal energy networks at scale, we need a balanced approach that allows innovation and learning to drive down long-term costs and ensure benefits are fairly distributed.

In the initial demonstration phase, regulators should provide guidance on key topics to ensure that the first projects work well:

- Reliability standards to meet customer heating and cooling needs.
- Simple initial rate-making methods, with a significant amount of revenue coming from sources other than the network customers.
- Rigorous data collection requirements to learn and avoid repeating mistakes.

However, as we progress through this initial phase, the need for an overarching regulatory construct that protects thermal energy network customers and drives down costs will be key to enable cost-effective expansion of this promising new service.

First, the *network itself* should be treated as a natural monopoly and subject to traditional utility regulation. Notably, this should include rate-making oversight to ensure just and reasonable rates based on the cost of service for investor-owned networks and an obligation to serve customers within a designated monopoly service territory. However, the *thermal energy resources* need not be treated as a monopoly, and network operators and regulators should appropriately consider non-utility resources, from customers and third parties, to create least-cost portfolios of thermal energy resources. There are several potential ownership models for the network, and it is important to have a clear and fair process for deciding which entity is responsible for thermal energy network service in different areas.

Second, network planning should start with simple feasibility and thermal resource adequacy criteria but will likely need to become more sophisticated to drive down costs. Network developers should be attentive to the availability of low-cost thermal energy resources and take the initiative to educate the public about thermal energy networks as a service option and ultimately acquire new customers.

Third, regulators can borrow rate-making structures from techniques and principles already used for other utility services. Initially, sophisticated customer metering may be cost prohibitive for all but industrial customers and significant thermal energy resources, which means rates for most customers may need to use a system of differentiated customer charges until metering costs fall substantially. For example, large residential customers, defined by square footage of heated/cooled space or size of customer equipment, could have a larger monthly customer charge than small residential customers.

Key Next Steps for Development of Thermal Energy Network Regulatory Framework

- Define key thermal energy network terms in statutes, regulations or orders.
- Establish process to designate provider service territories for new thermal energy network service.
- Require best practices for network data collection, including appropriate distribution to stakeholders and the public.
- Design fair customer service agreements.
- Determine rules to ensure sufficient thermal energy resources for given customer load.
- Set up uniform system of accounts for thermal energy networks.
- Investigate customer metering options while enabling simpler short-term rates.

Throughout the development of a regulatory framework, two needs are clear: first, collecting and sharing data and findings of all kinds to drive optimization and inform future work; and second, phasing the regulatory framework over time.

Considering our energy system and the needs it must meet in coming decades, it is important to envision how these new assets and service providers fit into the broader scope of utility oversight and energy planning. Integrated electric and gas planning is just beginning to be considered in a few jurisdictions, but thermal energy networks — as a significant *efficiency* option for electricity as well as an alternative to gas for heating — may spark accelerated adoption of integrated planning. While there is much complexity in the questions and processes considered in this report, it is clear that thermal energy networks have the potential to address several of the challenges we face today as we imagine the utility of the future.

1. Introduction

The overall goal of balance is frequently cited in public policy, where trade-offs must be understood and managed. But another concept of balance, finding equilibrium through constant adjustments, is integral to the operation of energy systems as well as the pursuit of progress and innovation over time. These concepts of equilibrium and adjustments are useful frameworks to consider as we introduce a new form of shared energy service, the thermal energy network, which can be used for both heating and cooling buildings.

The thermal energy network under discussion in many places today is a specific type of district energy system that combines long-proven technologies into a more novel utility-scale network. Each customer has their own heat pump or pumps connected to the network. The network pipes contain a circulating ambient temperature fluid, generally water or water based, that can be used as the thermal carrier for the heat pumps, allowing efficient operation year-round regardless of the outside temperature of the air. When the underlying thermal energy resource is the earth, these networks can be referred to as geothermal energy networks or networked geothermal.[1] But the more general term is a thermal energy network, which can include a variety of energy resources, including industrial waste heat or sewer systems. As long as the underlying heat sources have zero emissions, these thermal energy networks are carbon-neutral assets, although they require electricity to operate water pumps, controls, and the dedicated heat pump units for each customer.

The shared nature of these thermal energy networks offers benefits similar in kind to other network infrastructure. There are often economies of scale in the construction and operation of the network itself, and the fact that many different customers and customer types can use the network allows capacity investments to have higher utilization rates, effectively sharing the system costs. This phenomenon is known as the diversity of customer usage or load diversity. For example, if commercial customers use the network predominantly during business hours and residential customers use it predominantly at other times, everyone benefits by sharing system costs. In addition, centralized service through a common provider allows the system owner to act as the financing mechanism for all customers using the service.

As of March 2026, several thermal energy networks with a scalable ambient-temperature single-pipe design are operational in the United States, and many jurisdictions are now exploring this emerging technology as shown in Figure 1 below.[2]

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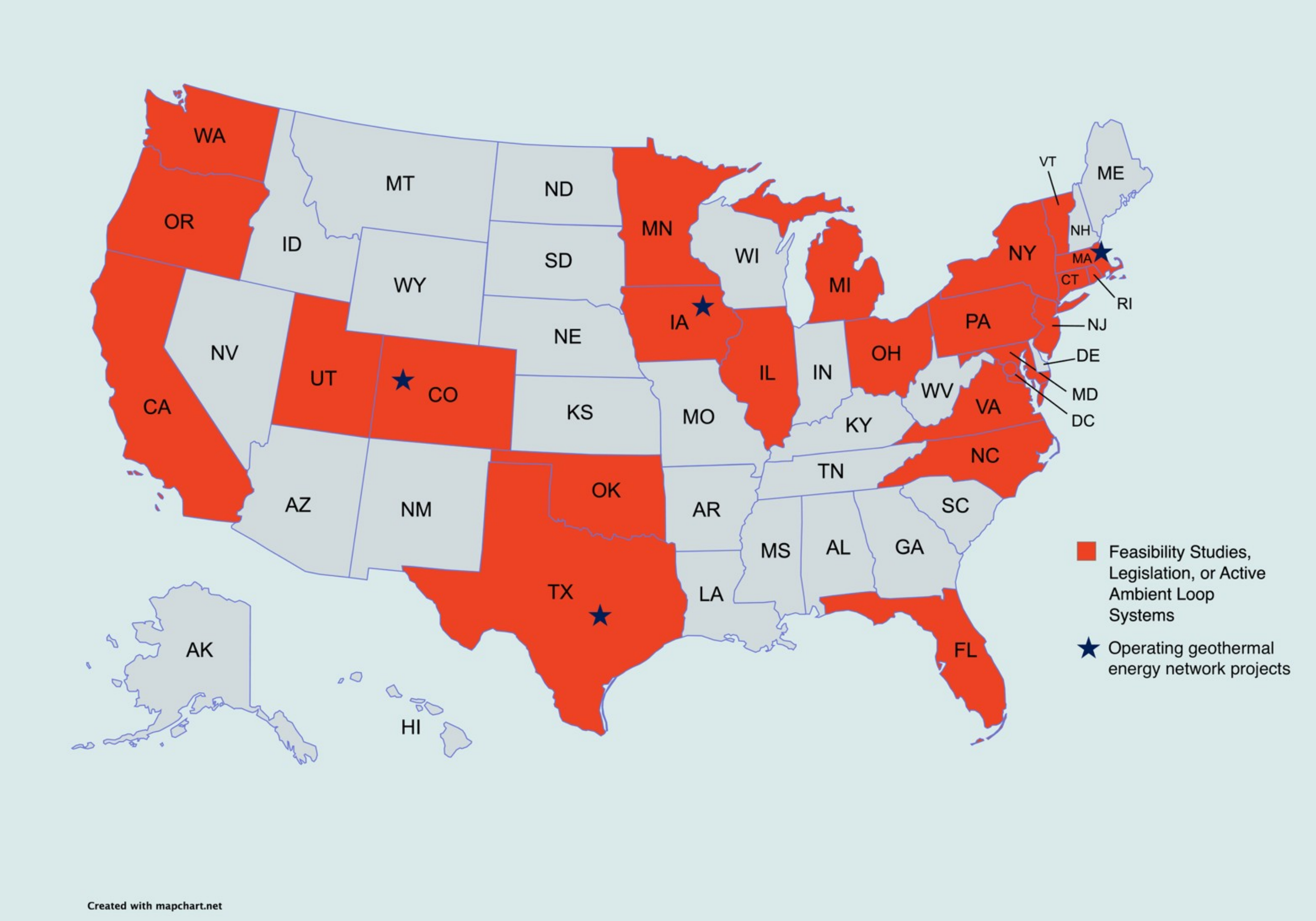
[1] See Magavi, Z., Alberto-Escobar, A., & Varela, I. (2024). A definitional taxonomy for (geo)thermal energy networks. *GRC Transactions*, *48*. https://cdn.prod.website-files.com/649aeb5aaa8188e00cea66bb/671b0629c6bc4b994c041c9c_2024_GRC_Taxonomy_Magavi_Alberto_Varela.pdf. When the earth is the main thermal resource for a network of this type, it is sometimes called networked geothermal or a geothermal energy network. This should be carefully distinguished from other geothermal technologies such as electricity generation, which uses heat from deep beneath the earth to produce steam, which then spins a turbine to make electricity. It also needs to be distinguished from geothermal direct use, which sources naturally hot water for use in buildings, spas or district energy systems.

[2] Outside of the United States, projects are in consideration in the UK, Belgium, Portugal, Ukraine, Türkiye, Jordan, Pakistan and Tajikistan. While significant portions of this report will be relevant in those jurisdictions as well, discussions of utility franchises, governance options and rate-making are focused on the United States context more specifically

Figure 1. Map of Engaged States and Operational Projects



Some of these initial projects include substantial support from the U.S. Department of Energy,[3] and in many cases this technology benefits from support from a federal investment tax credit.[4]

This report will assist policymakers, network developers and stakeholders in building a framework for regulating thermal energy networks and suggest important questions that warrant future investigation. The overall goal is to balance the need for regulation while still facilitating rapid technological and structural innovation. The remainder of this report is laid out as follows:

- Section 2 describes thermal energy networks in more detail and explains important distinctions from related technologies and systems.

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[3] U.S. Department of Energy. (n.d.). *District-scale geothermal energy pilots.* https://www.energy.gov/hgeo/geothermal/district-scale-geothermal-energy-pilots

[4] In 2024, the U.S. Department of Treasury clarified the circumstances under which geothermal heat pumps are eligible for the federal investment tax credit. "U.S. Department of the Treasury Releases Final Rules on Investment Tax Credit to Produce Clean Power, Strengthen Clean Energy Economy." (Dec. 4, 2024). https://home.treasury.gov/news/press-releases/jy2736. Unlike other investment tax credit provisions, eligibility for geothermal heat pumps through 2033 was not restricted or repealed by the One Big Beautiful Bill Act through 2033. The One Big Beautiful Bill Act: Considerations for Cities and Community Partners, (July 7, 2025). Sabin Center for Climate Change Law. https://blogs.law.columbia.edu/climatechange/2025/07/07/the-one-big-beautiful-bill-act-considerations-for-cities-and-community-partners/

- Section 3 discusses the basis for utility regulation of thermal energy networks, governance options and considerations for the evolution of regulation over time.
- Section 4 lays out key aspects of system planning, design, permitting and construction.
- Section 5 illustrates the issues around cost accounting, alternative revenue/funding sources and rates for thermal energy network customers.
- Section 6 touches on broader issues for the future of utility regulation across electric, gas and thermal energy options.
- Section 7 offers concluding thoughts.

2. Primer on Thermal Energy Networks

At the most basic level, a thermal energy network is a single pipe filled with water at an ambient temperature several feet underground, traveling in a loop or ring circling a neighborhood. Each customer is connected to the network by a service loop, consisting of an inflow (or supply) pipe and an outflow (or return) pipe. This arrangement allows for highly efficient heating and cooling using one or more heat pump unit(s) at each customer site. This can be described as a single-pipe ambient temperature loop. But we will use the term thermal energy network as shorthand and the abbreviation TEN in this policy brief. Thermal energy networks sit at the intersection of several different technologies, each of which has their own terminology and trends. We address three key distinctions in this section:

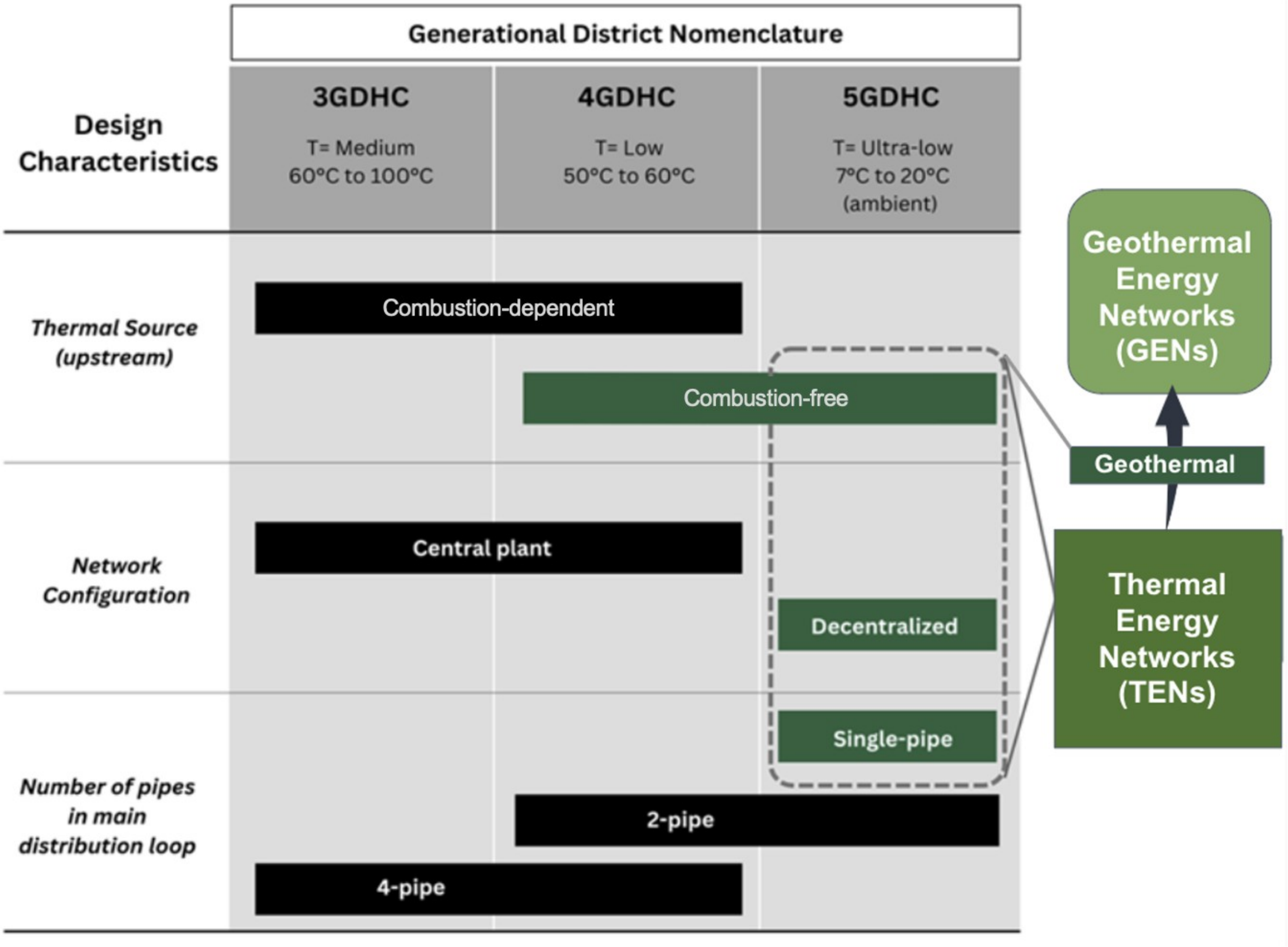
1. The difference between thermal energy networks and other district energy technologies.
2. The difference between heat pumps connected to a thermal energy network and other types of heat pumps.
3. The difference between geothermal resources used for a thermal energy network and other types of geothermal, as well as other categories of thermal energy resources useful for this type of thermal energy network.

While these distinctions are crucial to gain a clear understanding of what a thermal energy network is, it is also important to understand these details (e.g., detailed operation of heat pumps, the moving thermal storage provided by the network and the relevant operating issues for thermal energy networks) because they lead to key design and policy choices.

A. Types of District Energy

Historically, district energy systems have been designed around a central plant for a known set of customers or load and a controlled delivery temperature. While cooling can be provided by this central plant model, it is separate from the provision of heating. The evolution from fourth- to fifth-generation districts is a step change, decentralizing the generation of heating and integrating cooling through geothermal heating and cooling equipment (aka GSHP or geothermal heat pumps) in every customer building. Thermal energy networks are a type of fifth-generation district heating and cooling technology (5GDHC), distinguished from the majority of 5GDHC by the single-pipe loop design and wide design temperature window. These characteristics optimize system performance and allow for ease of adding or subtracting customers, loads, resources or additional loops, unlocking the potential for utility-scale deployment. These taxonomic relationships and the associated nomenclature are shown in Figure 2 below. In some ways, the geothermal energy network can be thought of as the result of a design fusion between geothermal heat pumps and district energy.

Figure 2. Diagram of Relationship Between District Energy and Thermal Network Technologies



Fifth-generation systems, including our definition of thermal energy networks as single-pipe ambient temperature loops, operate differently than previous generations of district energy technologies in key respects. They are enabled by modern heat pumps at customer sites, which can operate efficiently using lower temperature thermal resources. Because heat pumps operate at a lower temperature, they do not need high-temperature supply resources. Earlier generations of district heating systems often required combustion of fossil fuels or biomass to achieve those higher temperatures. Higher temperature water or steam allowed customers to use the temperature of the resource provided in a direct manner. Steam or hot water could be run through customer systems and equipment directly to heat a building or operate processes. Globally, most examples of modern district energy systems fall within the definition of the fourth generation. For example, the large HOFOR district heating system in Copenhagen, Denmark relies on biomass-fired combined heat and power as well as waste incineration.[5] The lower

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[5] HOFOR. (n.d.). *How to produce HOFOR's district heating.* https://www.hofor.dk/privat/fjernvarme/bliv-klog-paa-fjernvarme/saadan-producerer-hofor-fjernvarme/

temperatures for fifth-generation systems can be achieved with different types of resources and efficiently managed without combustion. For example, relatively low-temperature or ambient geothermal resources are suitable for a thermal energy network. When ambient (i.e., shallow) geothermal is a key thermal resource for a thermal energy network, such a system can be referred to as either a geothermal energy network or networked geothermal.

B. Heat Pump Operation and System Efficiencies

Modern heat pumps have undergone continual refinement from longstanding technologies to become workhorses of 21st century heating and cooling.[6] This technology shares much in common with refrigerators and cooling-only air conditioners. For refrigerators and air conditioners, a refrigerant gas is cycled using electricity to cool air inside the refrigerator or inside the building for air conditioning. For refrigerators, waste heat is typically expelled behind or underneath the unit. For air conditioners, the waste heat is typically expelled outside. A heat pump uses the same refrigerant cycle as those more familiar appliances but is more flexible. Most importantly, the refrigeration cycle in a heat pump is reversible, meaning that a user can choose which side gets heated and which side gets cooled. This allows a heat pump to be used for heating or cooling. In heating mode, heat pumps require a heat source, although such a source does not need to feel hot to the touch. Conversely, in cooling mode, heat pumps require a heat sink, which receives the heat being removed. Generically, these heat sources and sinks can be referred to as thermal energy resources. In most cases, heat pumps also use a thermal carrier, which connects the thermal energy resources with the refrigerant in the heat pump unit. Such a thermal carrier can be water or another refrigerant; though for geothermal heat pumps, the thermal carrier is nearly always water.

The full system — thermal energy resources, thermal carrier, and the refrigerant and heat exchanger within the heat pump unit together with design and control parameters — determines the efficiency of the heating or cooling application. The efficiency is mathematically defined as the coefficient of performance, which is the ratio between the thermal energy output of the unit and the amount of energy input required. For example, an air-source heat pump has an outdoor unit, which uses the open air as its thermal energy resource. For air-source heat pumps, the thermal carrier is a refrigerant that travels between the indoor and outdoor units. Even at room temperature, enough thermal energy is contained in the air to supply the refrigeration cycle in an efficient manner, although the operational efficiency does tend to go down at air temperatures below freezing or in extreme heat. A typical coefficient of performance (COP) for an air-source heat pump in mild weather is 3 or 4, meaning the unit in heating mode puts out three or four times as much heat as the electricity consumed.[7] This coefficient declines to 1 to 2 at

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[6] While the basic technology underlying modern heat pumps was discovered in the 19th century, innovations in the last several decades for refrigerants, variable speed controls and other key engineering features have transformed the efficiency and potential applications of the technology. Baraniuk, C. (2023). *How heat pumps of the 1800s are becoming the technology of the future*. Yale Climate Connections. https://yaleclimateconnections.org/2023/02/how-heat-pumps-of-the-1800s-are-becoming-the-technology-of-the-future/

[7] Chesser, M., Lyons, P., O'Reilly, P., & Carroll, P. (2021). Air source heat pump in-situ performance. *Energy and Buildings, 251*. https://www.sciencedirect.com/science/article/pii/S0378778821006496

temperatures below freezing or in extreme heat, but more innovative refrigerants can moderate this decline during extreme outdoor air temperatures.[8]

While this means that air-source heat pumps can be used for heating and cooling in almost any climate, other thermal energy resources and carriers enable a heat pump to operate at higher efficiency year-round in any climate. Individual buildings can install geothermal or ground-source heat pumps, which circulate water as the thermal carrier down into the ground or bedrock, using the temperature of the earth as the thermal energy resource. These systems, whether serving one or multiple buildings, frequently achieve coefficients of performance at 4 to 5 with little to no fluctuation during extreme outdoor air temperatures.[9] Of course, compared to air-source heat pumps, achieving these efficiencies does require additional upfront investment for the system of underground pipes providing the thermal energy, often including substantial drilling costs. These upfront costs can serve as a barrier to adoption, even when an individual building owner has reasonable access to financing options.

A thermal energy network shares much in common with geothermal heat pumps. For heat pumps connected to a thermal energy network, the thermal carrier is the liquid in the pipes. Water works quite nicely for these purposes, being relatively low-cost as well as having a high capacity to carry thermal energy. In certain climates, it may be a sound design decision to add a modest amount of antifreeze to the liquid, such as glycol, but putting the network pipes a moderate distance below the ground (e.g., 5 to 8 feet) also prevents freezing, as illustrated by water distribution systems. Modern plastic pipes (such as high-density polyethylene or HDPE) are widely used to transport water under the ground and within buildings and are perfectly suitable for a thermal energy network, as are steel pipes if preferred. While other district energy designs require multiple pipes, a single pipe is ideal for these thermal energy network loops. Pumping equipment, typically powered by electricity, is used to circulate water throughout the network. Each customer has an inflow pipe (supply) and an outflow pipe (return), which can be described as a service loop. This service loop runs through the customer's on-site geothermal heating and cooling equipment. The speed of water flow through the service loop typically depends on the operation of the customer's equipment.

As long as the water in the pipes remains within a reasonable temperature range, customers can use that water as a thermal carrier to heat or cool their buildings. For modern heat pumps, liquid at an ambient temperature is ideal as a thermal carrier for both heating and cooling.[10] This means that a reasonable temperature for the water ranges from approximately 35 degrees to 90 degrees Fahrenheit or 2 degrees to 32 degrees Celsius, which can be called the "design

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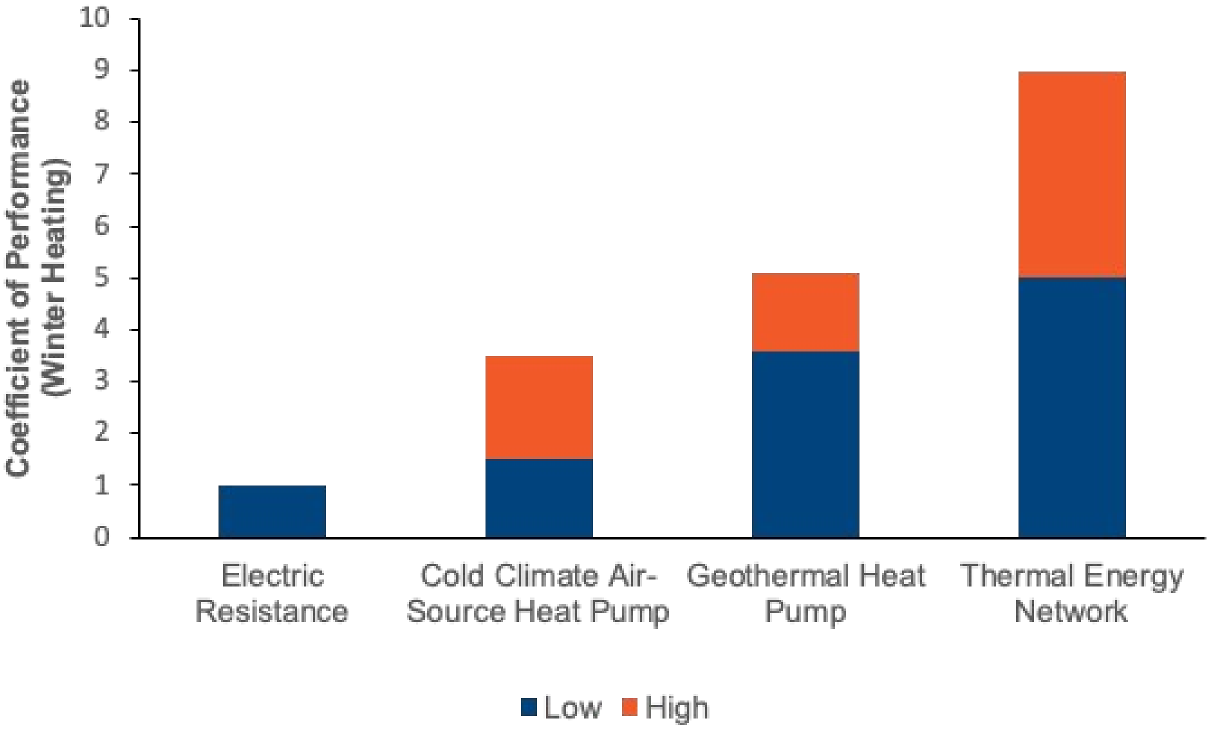
[8] Mendon, V., Keene, K., Rosenberg, S., Rotondo, J., Brambley, M., Young, J., Kazmi, A. A., & Delgoshaei, P. (2024). *Rising up to the challenge: Cold climate heat pumps in the field*. ACEEE Summer Study on Energy Efficiency in Buildings. https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Rising%20up%20to%20the%20Challenge%20-%20Cold%20Climate%20Heat%20Pumps%20in%20the%20Field.pdf

[9] Energy Star. (2025). *Energy Star most efficient 2025 geothermal heat pumps*. https://www.energystar.gov/most-efficient/me-certified-geothermal-heat-pumps/results?is_most_efficient_filter=Most%20Efficient

[10] A liquid is excellent for circulation. Hotter liquids make it more difficult for cooling, and colder liquids makes it more difficult for heating.

temperature window." Within such a temperature range, a thermal energy network allows for the highest level of operational system efficiency as shown in Figure 3 below. It is important to note that the thermal network uses system COP, which is like the COP of the individual heat pumps but also includes, for example, the pumping energy for the distribution infrastructure. The geothermal energy network at Colorado Mesa University routinely achieves a system coefficient of performance over 5 and even as high as 8.9 in the winter.[11] This means that thermal energy networks are a significant method for reducing winter peak electricity usage compared to alternative electric heating options, particularly electric resistance heating and air source heat pumps in cold climates.

Figure 3. Coefficient of Performance Comparison for Winter Heating Across Electric Technologies



Note: This comparison relies on a limited number of data sets for thermal energy networks to date.

However, keeping the temperature of the thermal carrier in this range is the challenge. The operation of the heat pumps by each customer, by definition, affects the temperature of the thermal carrier. Indeed, this is precisely the service provided by the thermal energy network to customers — the ability to put heat into or take heat out of the thermal carrier. As a result, a key design criterion of a thermal energy network is the ability to balance thermal energy resources —

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[11] Xcel Energy. (2022). *Evaluating a community ground source heat pump system at Colorado Mesa University.* https://www.coloradomesa.edu/sustainability/documents/cmu-cgshp-summary-2023.09.06.pdf

both heat sources and sinks — over time, to keep the thermal carrier within the ambient temperature range, thereby allowing customer equipment to operate efficiently.

C. Resources for Thermal Energy Networks

In principle, customers could be using the network in different ways so that the system would be self-balancing. For example, one building that needs cooling will reject heat into the thermal loop, which may be absorbed to heat a neighboring building. This is known as synchronous load cancellation, which may be the case for many months of the year.[12] However, at other times of the year, many customers may be using the network in the same way at the same time, for heating in the winter or cooling in the summer. This means that even in the most annually balanced network, independent thermal energy resources beyond those provided by the connected buildings, both heat sources and sinks, are typically needed to keep the thermal carrier within the efficient temperature range as it circulates.

It is this search for balance that drives the need for thermal energy resources to effectively design and operate a thermal energy network. As with a single-customer geothermal heat pump, the earth beneath our feet can serve as both heat source and sink for a thermal energy network. Because a thermal energy network operates at a relatively low temperature, ambient geothermal resources are suitable for these purposes. This should be carefully distinguished from deep high-temperature geothermal resources used for electricity generation as well as district energy systems for heating purposes or geothermal resources used directly by individual buildings. These different resources are displayed in Figure 4 below, along with a geothermal energy network on the far right.

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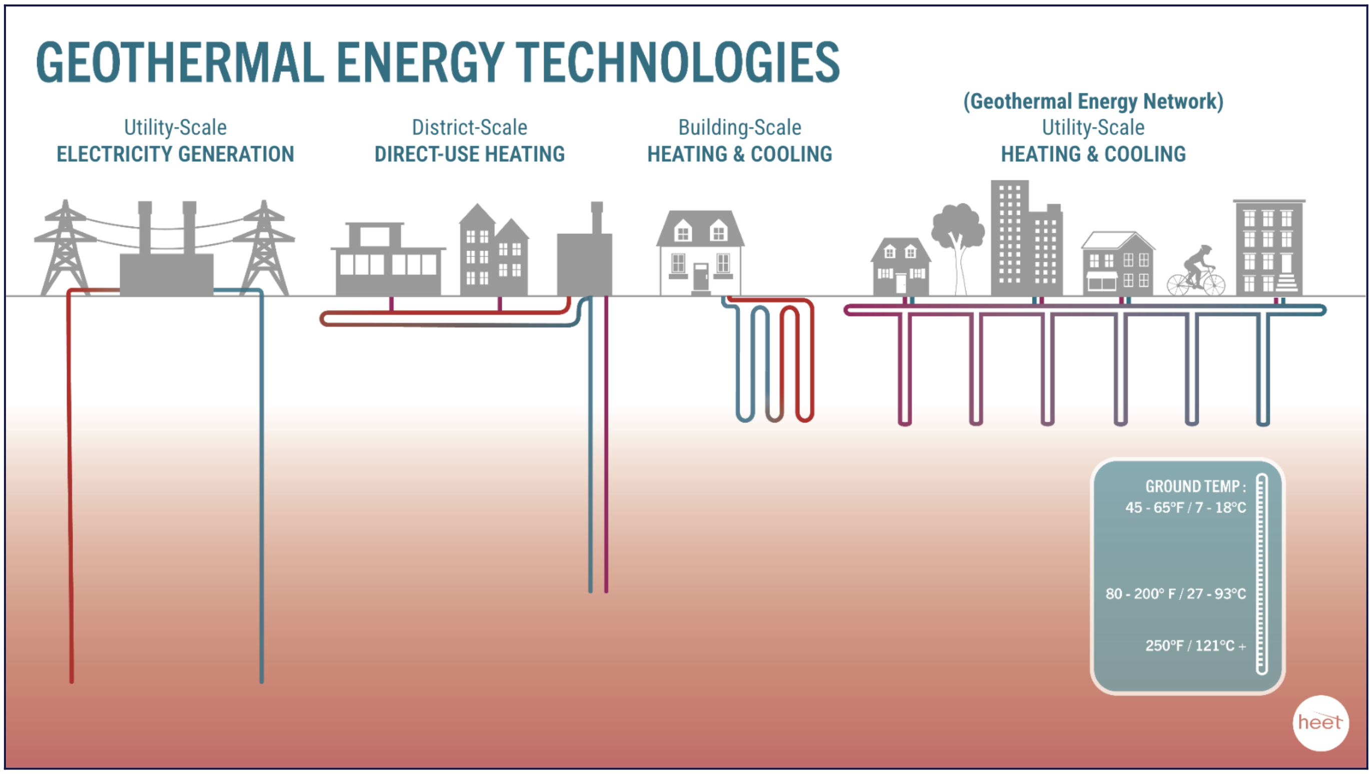
[12] See Electrical and Thermal Load Impacts of Three District Heating and Cooling Designs for an Existing Community in Washington, DC, Simpson, Juliet G., N. Long and W. Trainor-Gutton, National Renewable Energy Laboratory (Oct. 2025), https://docs.nlr.gov/docs/fy26osti/95498.pdf at p. 4 ("[District energy systems] also provide opportunities for load cancelling and load shifting by making use of the thermal inertia in the loops and diverse loads connected to it. 5G systems can efficiently shift heat from one building to another when there is a mix of prosumers that need heating and cooling simultaneously on the same [district energy system]…").

Figure 4. Differences Between Geothermal Energy Technologies



Within our definition of ambient geothermal for use in a thermal energy network, there are different configurations of geothermal exchange, which can serve the same essential purpose of accessing this ambient or shallow geothermal energy. For example, geothermal boreholes can go down as far as 2,000 feet to provide thermal exchange or a series of horizontal pipes can be laid just below the frost line[13] to provide the equivalent thermal exchange. Boreholes themselves can be vertical, directional, double-loop or concentric design. There are trade-offs between these different types of geothermal resources. A deep borehole requires minimal surface land area but is typically more expensive, requiring drilling. An array of pipes just below the frost line does not require sophisticated drilling equipment but does require disturbing a much wider surface land area.

Other existing assets may also serve as ambient temperature thermal sources and sinks for thermal energy networks. Bodies of water (natural or man-made), as well as wastewater and sewer systems, are examples of thermal energy resources that can be more cost effective than boreholes for thermal energy exchange when available. Figure 5 below displays a comprehensive conceptual categorization of thermal energy resources.

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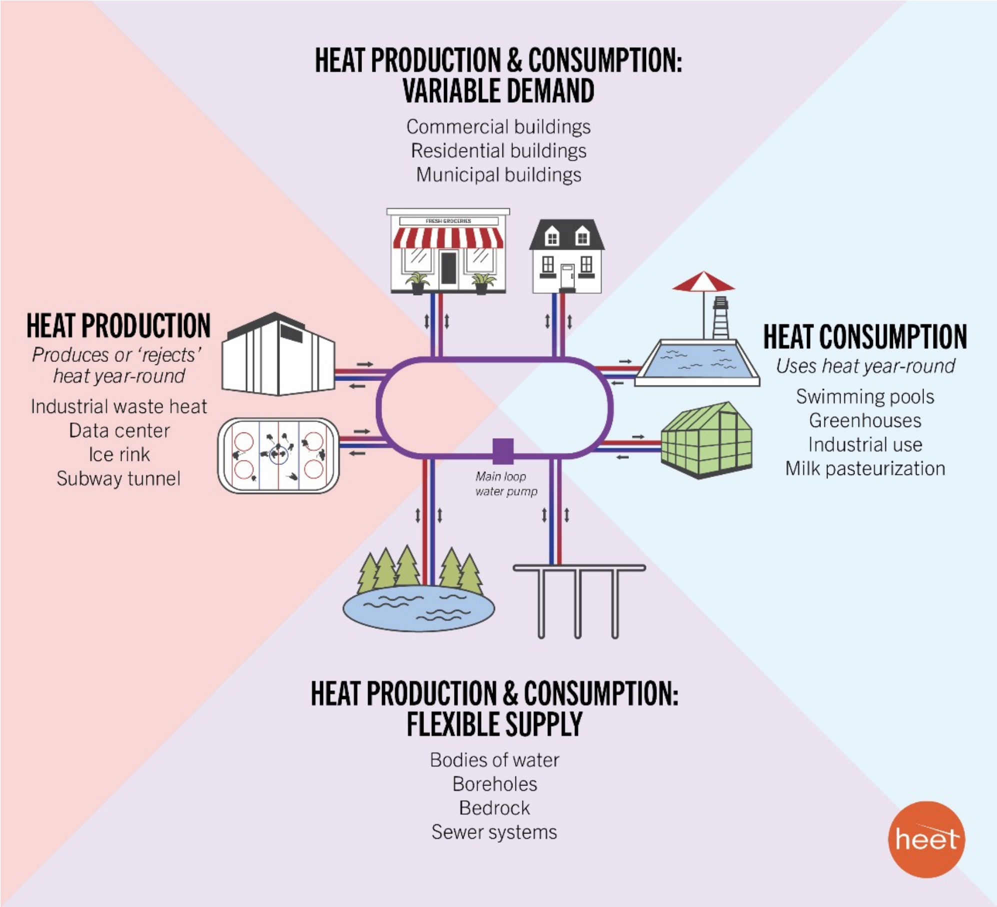
[13] The depth of soil where groundwater, or the water in pipes, would not freeze in local winter conditions.

Figure 5. Conceptual Categorization of Thermal Energy Resources for a Thermal Energy Network.



Importantly, many thermal resources are impacted by the operation of the thermal energy network. In the summer, when buildings are operating their heat pumps for cooling, waste heat gets transferred into the thermal carrier and ultimately into the thermal resources, warming the earth or the body of water. The reverse is true when buildings need heating; heat is ultimately pulled from the earth or the body of water. The impacts of such heating or cooling should be considered carefully with many nuances. A river, wastewater or sewer system can provide or absorb thermal energy at a given rate depending on flow but typically does not provide thermal storage. In contrast, a fixed body of water, the earth, or bedrock is a thermal resource that often has a sufficiently slow dissipation rate to allow for some thermal energy storage function. The quantification of both the thermal capacity and the thermal flow or dissipation rate are therefore key to understanding appropriate use of such ambient temperature thermal resources. The ideal set of thermal resources is well balanced annually to avoid thermal drift, where the temperature of the subsurface ground or water body changes significantly over years. However, the thermal energy network operator has the capacity and the responsibility to measure, monitor and address imbalances or adjust thermal capacity over time, adding resources or even using conventional equipment such as electric boilers and chillers if necessary. This allows for adaptability to changing customers and loads but also, for example, to a changing climate. Over the last several decades, the temperature of ponds, lakes and rivers has risen considerably in many places. Drawing down this thermal energy through thermal networks, or even industrial scale heat pumps,[14] can help to restore waterways to historic baseline temperatures, with the potential to yield ecosystem benefits while heating buildings.

In addition to ambient thermal resources, there are certain types of facilities that require either heating or cooling year-round and therefore can act as a consistent thermal resource as part of the operation of the thermal energy network. Examples of facilities that use heating year-round include milk pasteurization, beer brewing and some greenhouses. These customers can be considered a demand in the winter but effectively serve as a supply resource in the summer. With respect to cooling, data centers, grocery stores and ice-skating rinks are examples of places that need to eliminate heat constantly. This type of customer can be part of the operation of the overall thermal energy network, effectively as a supply resource in the winter and as a customer load in the summer. Industrial waste heat, in the context of a thermal network, can be conceptualized similarly.

The location and the scale of the thermal energy resources used for the network are designed to match the distribution network and the customer base as well as to ensure that annual thermal demands, including system coincident peaks, are met reliably. If the original design estimates were inaccurate or the customer demands change dramatically, ongoing monitoring of the thermal energy network allows for adaptation. Given the slow rate of thermal drift, the addition of thermal energy resources, such as a few more geothermal boreholes, can typically be planned and installed before the thermal drift affects customer equipment performance to any significant degree since the range of temperatures for efficient heat pump operation is relatively wide.

While it is not necessarily the lowest-cost thermal resource, a vertical geothermal borehole is the most universally applicable at the smallest unit of a thermal energy network. Those smallest, first demonstration projects are the most challenging to balance in a cost-effective way and considerable effort should be made to minimize this challenge through site selection. As the customer base increases and the thermal energy network scales, the load predictability and the thermal inertia of the system reduce the thermal resource requirements. At larger scales, larger thermal resources such as industrial waste heat, data centers and dedicated thermal storage become more likely to be appropriate and cost effective. Given the very low temperature differential between the ground and the liquid thermal carrier in the distribution network, the thermal energy losses over distance are low, meaning that such thermal energy resources can potentially address thermal demands miles away. As a network scales, the capacity to include and utilize intermittent thermal energy resources effectively increases. While the distribution and availability of particularly cost-effective thermal energy resources may drive initial site selection, the universal scalability of this technology will likely be reliant on ambient geothermal energy.

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[14] Vicinity Energy is doing just this in the Charles River in Massachusetts. See Chesto, J. (2023, May 1). A new energy source for downtown Boston: The Charles River. *Boston Globe.* https://www.districtenergy.org/blogs/district-energy/2023/05/04/a-new-energy-source-for-downtown-boston-the-charle#:~:text=Summary,being%20constructed%20by%20developer%20IQHQ

The everywhere, always on, non-intermittent reliability of ambient geothermal energy is one of the strengths of this technology and is also a key factor in meeting energy independence, energy security or emissions reduction goals. These goals, as well as resilience, reliability and affordability goals, additionally depend on the electricity supply utilized for the system pumps and customer heating and cooling equipment. It is of note that the thermal energy network distribution infrastructure and its system performance advantages are independent of the thermal energy resources. This allows a strategic or incremental evolution over time in the selection of thermal energy resources, just as the electric generation system will continue to evolve over time.

3. Regulatory Approach and Governance Options

Energy policy in the United States is designed to serve a broad range of high-level policy goals, which also apply to utility regulation. Utility regulation serves a resulting broad array of intertwined public policy goals, which are evolving and continue to add new expectations on energy providers to accomplish an expanding set of objectives. While these complex webs of important considerations can be sorted many ways, it is useful here to describe them as falling into five key categories: (1) cost control and affordability, (2) provision of safe and reliable service, (3) societal equity, such as universal service, (4) economic development and employment and (5) public health and environmental protection.[15]

With these policy goals in mind, working out the details of a regulatory framework for a new energy service provides an opportunity to evaluate an approach from first principles. Given both the natural monopoly characteristics of local distribution networks and the practical realities of infrastructure installation and maintenance, adopting a franchise model with monopoly service territories for thermal energy networks is likely to be a preferrable arrangement to a fully competitive market for this service. Important issues do arise around how to enlist non-utility-owned resources into a least-cost portfolio as well as how to implement reasonable rules for sharing common pool thermal energy resources. For a new service without existing providers, this does raise the question about how monopoly service providers are chosen in a given area. Having a clear process to choose a provider is important, and a broad array of considerations likely apply. In addition, the earlier stages of thermal energy network development warrant a more flexible regulatory approach focused on innovation and driving down long-term costs before transitioning to a full utility regulatory framework.

A. Regulatory Framework

A threshold question is whether thermal energy networks should be installed and offered on a competitive basis without direct economic regulation of prices or treated as a regulated monopoly akin to more traditional utility services. Two primary categories of rationales have been offered to support conclusions that a given industry or provider should be appropriately considered a monopoly and subject to direct price regulation.[16] The first is primarily economic, where a single provider can definitively provide service at a lower price than multiple providers, meaning that any scenario with multiple providers is necessarily unstable and will inevitably lead to a single provider winning out over time and gaining a monopoly. This is what is known as a “natural monopoly,” a phenomenon observed by John Stuart Mill in London in 1848 for gas and water service.[17] Modern economics has associated this situation with the term “economies of

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[15] Administrative feasibility is another key practical concern, and gradualism, while not a policy goal by itself, is a frequently cited principle in utility regulation.

[16] It should be recognized that in many other situations the appropriate remedy for a monopoly has not been considered a recognition of the monopoly with any economic regulation. In many other circumstances, the appropriate remedy is the restoration of competition in the relevant markets through either the breakup of the single company (e.g., Standard Oil in the 1910s or AT&T in the 1980s) or the imposition of other rules to fairly allow for competition among multiple companies.

[17] Garfield, P. J., & Lovejoy, W. (1964). *Public Utility Economics*, p. 15. Prentice-Hall.

scale," and subsequent technical work has further refined it mathematically to the concept of "subadditivity."[18] In practice, such a conclusion also indicates that a single provider can be least cost, meaning a monopoly can be best for consumers. The second category of rationales centers around practical considerations of usage and access to physical space. For underground infrastructure, tearing up streets to install, replace or otherwise maintain two systems would be disruptive to local activities and the general public. Similarly, for above-ground infrastructure such as the electric grid in many places, multiple sets of distribution wires in public spaces has been considered unsightly and sometimes unsafe.

One distinguishing characteristic that applies to thermal energy networks and other economically regulated entities is the local delivery infrastructure that connects individual buildings to a shared network. It seems clear that, from an economic perspective, the thermal energy network itself almost certainly constitutes a natural monopoly, just like electric and gas distribution networks. Having two thermal energy networks competing for customers in a particular geographic area would be unstable; whichever provider has more customers would likely be able to offer lower rates thus pushing its competitor out of the market. In addition, the growing efficiency of a thermal network as it expands, increasing its thermal inertia, load predictability and ability to connect to larger scale thermal resources, makes it likely that a single provider lowers the cost of service in comparison to multiple providers, each serving one block with individual thermal energy networks. And then, in a manner similar to underground gas or underground electric infrastructure, having two sets of thermal energy networks in a given area doubles the cost and inconveniences of installation and maintenance to the public. Furthermore, the thermal energy network, unlike most electric and gas networks, is dependent on local thermal energy resources of a limited supply.

The necessary conclusion from this is the same as for electric and gas distribution networks. A monopoly for given network locations should be recognized while providing for economic regulation to avoid that monopoly exercising its market power in pricing or engaging in other forms of anti-competitive behavior. In addition to the above two rationales, direct economic regulation can provide benefits to both investors and consumers if implemented as a fair bargain. The objective of price regulation generally and cost-of-service rate-making in particular is to balance the provision of safe, adequate and reliable service while ensuring that prices and revenues are sufficient, but no more than sufficient, to compensate the regulated entity for its cost of providing service.[19] Private owners can see a clear pathway to recover their costs and achieve a fair rate of return. While rate regulation can certainly be improved across the United States, consumers have assurance that prices will not be manipulated and that there will be a public process for consideration of rate increases.

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[18] Baumol, W. (1977, December). On the proper cost test for natural monopoly in a multiproduct industry. *American Economic Review*, *67*(5), 809-822.

[19] Lazar, J. (2016). *Electricity regulation in the US: A guide*, 2nd ed., pp. 5-6. Regulatory Assistance Project. http://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2

The Obligation to Serve for a Thermal Energy Network

The grant of an exclusive franchise to an entity typically comes with an obligation to serve customers within its designated service area, as long as those customers are willing to pay their bills and meet the other terms and conditions for service. For new customers, that sometimes includes an upfront financial payment, known as a contribution in aid of construction, to make the extension of service economic for the utility and its other customers.

The obligation to serve is considered a crucial aspect of monopoly utility regulation for two related reasons. First, without such an obligation, a monopoly provider could pick and choose who gets served in ways that are either suboptimal economically or just unfair. It could focus exclusively on maximizing profits, providing service to areas or customers with the highest profit margin, or it could cut off customers that oppose rate increases.[20] Given a monopoly franchise, those customers would not be able to receive service from another provider. Second, ensuring universal access is an important public policy objective because utilities provide essential services for the well-being of society.[21]

Which services are essential may evolve over time, for example, shifting from delivery of gas to delivery of heating as discussed in section 6 below. Even where a service is considered “essential,” a utility’s obligation is not without bounds; utilities are often exempt from continuing to provide service to nonpaying customers or extending service to customers located too far from the rest of the utility system without a sufficient contribution in aid of construction. Like the definition of the obligation itself, these limitations on the obligation’s scope may also be adjusted to address public policy priorities. For example, regulators have relied on equity principles to ban customer disconnections for nonpayment when heating or cooling is essential to customer health or public safety.

While the network itself can reasonably be considered a monopoly, the thermal energy resources that serve to balance the network may represent a different case. The network owner and operator can have thermal energy assets connected to the network (e.g., geothermal boreholes directly connected to the network). However, third-party thermal energy resources and customers themselves could plausibly serve as economically viable resources to help balance the network. If this is the case, a range of roles for competition could be designed for this purpose in a mature network, much like with electric or gas commodity supply in most jurisdictions or wholesale electricity markets in some regions.[22] So on balance, the correct role of regulation for thermal energy networks is likely to be the designation of a single provider in a given location and direct economic regulation of any private entity owning and operating the network, while recognizing that competition and multiple providers may have a role in the acquisition and operation of thermal energy resources. Additionally, private networks on campuses or existing conventional district energy systems of varied design can themselves be contracting thermal resources to the shared thermal energy network.

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[20] Hempling, S. (2021). *Regulating public utility performance: The law of market structure, pricing and jurisdiction,* 2nd ed., pp. 44-45. American Bar Association.

[21] Lazar, 2016, 3.

[22] Note that, as with many wholesale electricity markets, demand-side resources may be able to play a significant role as resources for thermal energy networks.

There are certain situations where utility regulation may not be appropriate. It is the shared multi-customer nature of the network infrastructure that justifies economic regulation. To pick a clear differentiating case, individual building geothermal heat pump installations are not a monopoly, particularly if more than one company is competing for customers in a given area. Customers can choose among multiple potential providers or choose not to install a geothermal heat pump at all, just like a customer’s choice for water heating equipment or a television. Similarly, a multibuilding campus owned by one entity is in the same situation, even though the relevant infrastructure looks more like a network. Ideally, the campus owners choose, as they do now, among multiple competing providers for their energy equipment and services while having the opportunity to sell or buy thermal resources through neighboring networks. Additional de minimis exceptions to utility regulation have been created in different states.[23] For example, any company providing service to fewer than 25 customers is exempt from utility regulation in Minnesota.[24] More specifically, the New York Public Service Commission issued an order laying out initial thermal energy network rules in July 2024, including exemptions for small-scale thermal energy networks not owned by utilities that meet specific criteria.[25]

While many different types of entities could build thermal energy networks and provide service to customers, more comprehensive versions of economic regulation have been used by state public utility commissions when a private company, such as an investor-owned corporation, owns and operates a utility.[26] While the details vary from jurisdiction to jurisdiction across the United States, investor-owned utilities of many kinds are generally subject to price regulation, along with rules for network access, requirements for service quality and restrictions on entry. For electric or gas service, this typically means that a utility has a monopoly service territory where no other providers can operate but where they must provide safe, reliable and nondiscriminatory service at just and reasonable rates. In the case of a thermal energy network, it may also be linked with grant of access to the thermal commons, geothermal resources that are without boundaries but finite in a given time period. There are practical concerns about joint usage of a common resource when the earth or a widely accessible body of water serves as a thermal energy resource. (See callout box on the following page.)

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[23] This may be the fundamental reason why district energy services have not been subject to utility regulation in most jurisdictions to date. They tend to serve a limited number of more sophisticated commercial and industrial customers.

[24] Minnesota Office of the Revisor of Statutes, 2025 Minnesota Statutes, Section 216B.02 Definitions, Subd. 4. Public Utility. https://www.revisor.mn.gov/statutes/cite/216b.02

[25] New York Department of Public Service, Case 22-M-0429, Order Adopting Initial Utility Thermal Energy Network Rules, July 18, 2024, p. 26. https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=68607

[26] When nonprofit or governmental entities provide utility services, these entities still must choose methods for setting prices and terms of service but are not typically subject to the jurisdiction of the state public utility commission.

The Idea of a Thermal Commons: Definitions and Regulation for Sharing a Common Energy Resource

Who owns the thermal energy beneath our feet? While access to locationally specific hot geothermal energy has followed permitting, access and ownership structures akin to oil and gas resources or mineral resources law, the ambient temperature geothermal used by thermal energy networks does not fit that approach. Instead, it is a better match to riparian law or other boundary crossing, “common pool” resources that are both useful and finite. HEET has proposed a specific set of definitions for geothermal energy[27] to allow for both fair and sustained resource maintenance:

> "Geothermal energy", thermal energy found at or below the surface of the earth including within (i) the soil and the bedrock, (ii) the surface water including the rivers, ponds, lakes within the commonwealth and the sea adjacent to the commonwealth, and (iii) the water beneath the surface of the earth within the commonwealth including groundwater, springs, and aquifers.
>
> “Ambient geothermal energy”, geothermal energy from a resource measuring 80 degrees Fahrenheit or less.
>
> “Hot geothermal energy”, geothermal energy from a resource measuring 80 degrees Fahrenheit or more.
>
> “Anthropogenic geothermal energy”, ambient geothermal energy in excess of the average temperature baseline in the year 1900 A.D., compared to the average temperature of the most recent year reported by the National Oceanic and Atmospheric Administration’s National Center for Environmental Information.

The ambient geothermal energy, including anthropogenic geothermal energy or “anthrothermal”, are a “thermal commons” that should be held in the public trust and managed to benefit human society. Some necessary considerations for this thermal commons include:

- Setbacks from property boundaries for geothermal heat exchange, to avoid thermal interference.
- Different usage requirements and regulations for anthropogenic and nonanthropogenic thermal energy, ideally incentivizing the drawdown of anthrothermal and the maintenance on an annual basis of ambient thermal, and that including the scope of thermal drawdown and how much thermal energy is considered anthropogenic.
- Potential obligations to provide public service or be publicly regulated when granted access to ‘tap’ the thermal commons.

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[27] An act relative to the protection and development of the thermal commons of the commonwealth, H.B. 3543, 194th General Court (Mass. 2025). https://malegislature.gov/Bills/194/HD4012.Html

B. Governance Options

Of course, whether a monopoly exists by law or in practice does not dictate *which* provider will serve customers in a given area; it just dictates that two entities cannot build infrastructure in the same location. Much like other energy services and products, several different kinds of entities could own and operate thermal energy networks. That includes investor-owned corporations, government entities and shared customer ownership through cooperatives.[28] Within each of those categories, there are options to sort through. An investor-owned utility seeking to offer thermal energy network services may be related to an existing electric or gas utility serving that same area, but it could also be independent of the incumbent utilities serving the area. Similarly, if different electric and gas utilities serve a given municipality, both utilities may have an interest in expanding into thermal energy network service. First and foremost, a clear process is necessary to decide who has the right to the monopoly in any given area or municipality.

While innovation on this front should be considered, particularly in light of the novelty of this utility service, many jurisdictions have existing statutes and processes with respect to exclusive retail franchises for utilities. A franchise designation confers on an entity the right to be the sole provider of a defined service within a designated service territory, in most cases legally prohibiting others from offering those services in that area.[29] In many states, a franchise is provided through a determination of the state's public utility commission. In other jurisdictions, local government may have the final decision. While such a franchise may be granted for a designated number of years or indefinitely, it may also be revokable or otherwise subject to conditions. If an incumbent utility provides poor service, for example, a new company may be able to seek access to that utility's service area.[30] This may also be allowed where the incumbent utility lacks new or modified services that a new entrant could provide. Similarly, if a franchise is given for a certain number of years, it could be subject to competitive bid at the conclusion of each franchise term. Franchise agreements and obligations for large investor-owned utilities come with a significant administrative burden, and many jurisdictions provide a lighter form of regulation for smaller investor-owned utilities.

For established utility services, franchise statutes support the broader utility regulatory framework in a landscape where service territories have long been established. For a new option like thermal energy networks, there is a blank slate where a fair process is needed to set boundaries. Substantively, the pros and cons of each option should be weighed appropriately. Incumbent utilities may be well suited to accelerate the adoption of thermal energy networks in some jurisdictions but should not be allowed to block cooperatives, government-owned options and innovative new private entrants without reason. Information gathered from initial projects

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[28] Individual customers can own their own systems, whether that is a residential homeowner or a university with a campus of buildings. The former example is typically described as a geothermal or ground-source heat pump installation, and the latter has more structural similarities to a network.

[29] Hempling, 2021, 14.

[30] Hempling, 2021, 38-41.

may help inform these decisions broadly, as well as the optimal scale for thermal energy network service. But each option may be considered in turn.

First, joint ownership of thermal energy networks by investor-owned utilities, whether formally part of the same corporation or not, may provide synergies that could assist in the development of thermal energy networks, particularly in these early stages. TENs could be well suited to address common policy goals, such as energy independence, security, affordability, safety or building decarbonization at scale by leveraging utilities' right-of-way and by bringing considerable resources to bear, including their existing in-house workforce to construct, operate and maintain these systems.[31] Gas utilities in particular may be interested in developing a TEN as an option to complement or replace existing service for many different reasons. That includes the need to address capacity constraints and moratoria, as a method of improving safety, to insulate the gas utility business model from commodity price volatility or to expand the business model to include cooling as cooling demand increases. As a utility-owned asset within the same corporation as the gas utility assets and employees, the TEN would logically be subject to nearly the same oversight and regulation as the gas utility itself. For example, the Eversource gas utility affiliate NSTAR Gas has developed a utility-scale, networked geothermal system pilot in Framingham, Massachusetts. The TEN includes 36 buildings, 24 of which are residential homes. Through the pilot, Eversource is exploring development of TENs as an alternative business model that meets state mandates around decarbonization while addressing other customer needs such as cooling. The pilot was commissioned in June 2024 and is scheduled to run for two years.[32] However, electric utilities or existing district energy companies may have their own expertise and interests that could be leveraged to develop utility-scale thermal energy networks, as well as the possibility of stand-alone investor-owned thermal energy networks.

Besides investor-owned utilities, several other types of entities provide utility services in this country, which are governed and regulated by different rules. Government entities own and operate most water utilities across the country but also many electric utilities and some gas utilities. When owned by a city or town, these municipal utilities are typically governed directly by the municipality or through a special elected commission. States also own and operate electric utilities or assets in several cases, with special statutory governance arrangements. In most cases, these municipal or state utilities are not subject to significant additional regulation by the state utility commission.

In 2026, municipal ownership of a thermal energy network is planned in the City of Ann Arbor, Michigan.[33] Municipal ownership of a thermal energy network is similar in structure and responsibility to a municipal water or sewer department, or other municipal agencies or

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[31] Cohen, R., Nguyen, L., & Smith D. C. (2024). *Understanding thermal energy networks.* Cornell University School of Industrial and Labor Relations, Climate Jobs Institute. https://www.ilr.cornell.edu/sites/default/files-d8/2024-12/understanding-thermal-energy-networks.pdf

[32] Eversource. (n.d.). *Networked geothermal systems*. https://www.eversource.com/content/residential/save-money-energy/clean-energy-options/geothermal-energy/geothermal-pilot-framingham

[33] City of Ann Arbor. (n.d.). *Geothermal heating and cooling.* https://www.a2gov.org/sustainability-innovations-home/sustainability-me/for-families-individuals/geothermal-heating-cooling/

corporations that are contracted to provide services on behalf of a municipality. Municipal ownership ensures local control and regulation, which can keep decision-making in line with community priorities. Municipalities have the ability to shape a TEN through zoning and municipal planning, which can ensure equitable impacts if low-income and disadvantaged members of the community are prioritized. A municipality can also coordinate TEN development with other local economic development and decarbonization efforts. Municipalities have established stakeholder relationships and community systems. Local elected officials, who oversee the TEN, are accountable to voters.

Municipal TEN ownership has its share of challenges as well. However, municipalities with fewer resources may not have the personnel or financing capacity to undertake this type of venture, potentially shifting the benefits of municipal ownership of TENs disproportionately away from low-income and disadvantaged groups. The pace of project development can depend on local politics, budgets and planning capacity. Municipal leaders and staff may lack technical expertise. TEN development and expansion may be subject to local political challenges. Some of these challenges may be reduced by establishing a new municipal corporation or a special district to manage a TEN. A municipal corporation is an entity authorized by the state to administer local affairs. Municipal corporations can be given the bonding capacity to develop and complete projects on their own. They have a separate governance structure and are overseen by a board of elected officials or appointees. Special districts are local governments created by communities to deliver specialized services to that community.[34] Municipal corporations and special districts have the benefit of more autonomy, which can reduce red tape and move projects along more quickly. They also isolate the surrounding municipality from project risks, potentially reducing the political and economics barriers to TEN development.

Cooperatives, or co-ops, are another common type of entity to provide utility service, particularly for electricity since they were encouraged by the Rural Electrification Act of 1936. Co-ops are private, member-owned nonprofit corporations that are typically governed by a board elected by the customers of the utility. However, because co-ops are owned by their customers and the rules and rates are set by the elected boards, these service providers are most often not subject to further state utility regulation. The Rochester District Heating Cooperative is a customer-owned, nonprofit entity that provides thermal energy to more than 8.5 million square feet of space across dozens of buildings in downtown Rochester, New York.[35]

A cooperative TEN ownership model requires joint control of the entity that owns and manages the TEN. Co-op members may be TEN customers or possibly suppliers of thermal energy to the TEN. In a cooperative ownership model, net revenues can be shared among members or saved as a cash reserve. Cooperative ownership means self-governance and often local control, which can help ensure equitable project outcomes and the fair distribution of resources and benefits. The local nature of cooperatives can foster a sense of shared identity and ownership, which can

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[34] National Special Districts Association. (n.d.). *About special districts.* https://www.nationalspecialdistricts.org/about-special-districts

[35] Rochester District Heating Cooperative. (n.d.). *Transforming energy in downtown Rochester.* https://rdhc.org/

enhance local participation in a project and may help reduce potential conflicts or hurdles in project implementation. Smaller cooperatives may be easier to manage. However, cooperative initiatives rely on voluntary participation, and they may struggle to find enough physically proximate members, especially if located in a rural area. Buy-in may be expensive for individual members, especially in smaller cooperatives where project costs will have to be shared across fewer members.[36] As with municipalities, co-ops may have less access to capital for infrastructure build-out than larger entities, and smaller ratepayer bases to carry that debt, potentially making the cost of capital higher.

It is also true that existing district energy companies have many of the skills needed and a business model that is close to that required by utility-scale TENs. In the United States, however, the deployment of district energy is rarely regulated in the same way as IOUs and does not require an obligation to serve. The traditional centralized architecture of prior generations of district energy constrained growth and made it logical for these companies to maintain the ability to serve a selected set of customers. It may be necessary to explore this boundary between district and network to ensure that the degree and detail of any regulation is appropriate to each.

C. Evolution of Regulation as Technologies Mature

While utility-scale thermal energy networks utilize well-established component technologies, their design, interconnection and integration into current energy systems represent a novel set of organizational and planning challenges. The first projects need to balance cost control with experimentation to better understand optimal design, procurement and implementation. Because thermal energy networks are novel with many issues to resolve, the early stages of implementation will include learning and optimization costs, but the data thus accrued is an investment in future implementation and cost reductions. As discussed below, the first TENs provide crucial data and findings for cost-effective implementation. If thermal energy networks are to succeed and scale, costs will need to fall as new TENs are developed and existing ones expand. Per-customer costs would then fall as scale yields greater efficiencies and fewer mistakes and better designs optimize and balance networks. Renewable energy technologies such as solar and wind have shown rapid learning curve rates of roughly 20%, meaning a 20% reduction in cost for every doubling of cumulative capacity.[37] Initial indications from the thermal energy network expansion project in Framingham, Massachusetts match or exceed this expectation.[38]

The challenge then is how to oversee thermal energy networks over time. This is similar to other areas of energy policy, where infant industries with significant promise can and should be

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[36] Vermont Community Thermal Networks. (n.d.). *How to develop a thermal energy network.* https://www.vctn.org/toolkit

[37] See Renewable Power Generation Costs in 2024, International Renewable Energy Agency (2025), at p. 59, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Jul/IRENA_TEC_RPGC_in_2024_2025.pdf

[38] Case Study: Framingham, Massachusetts (n.d.), Building Decarbonization Coalition, https://buildingdecarb.org/resource/case-study-framingham-massachusetts

nurtured. But a timely transition to a mature industry framework should be planned carefully as well. We propose conceptualizing this process as three phases: (1) demonstration, (2) development and (3) deployment. Over time, thermal energy network regulation should also be integrated with other energy and utility regulatory policies. These policies will not be static either. For example, integrated electric and gas utility planning is in its infancy as well.[39] Weaving thermal energy network considerations into such integrated planning will require additional thought but may also be a key driver of integrated planning reforms.

Demonstration refers to the very first projects to be built, which is the current stage for thermal energy networks in the United States. These first projects will be the most expensive, for many reasons. For utilities, these are often pilot projects, possibly requiring specific authorization. This is the steepest part of the learning curve, including learning about geology, drilling and labor. This is also a critical phase for education and customer engagement to foster understanding and support for deployment. Accessing thermal resources may require new contracting and collaboration among different entities. It may be necessary to measure or map thermal resources and seek specialized review from other state agencies. In the demonstration phase, key goals should be to:

- Assess and establish the viability and potential of the technology to meet utility, customer, municipal and state needs and goals.
- Collect data regarding costs and cost drivers, efficiencies and optimal design for each region.
- Educate customers, communities, policymakers and other stakeholders.
- Understand challenges and manage potential points of failure.
- Foster innovation in the design, implementation and management of thermal energy networks.

Development will be the next phase, where data gathered earlier can start to be applied. In this second stage, key questions begin to be answered, such as how to:

- Optimize design parameters and lower costs, including identifying and exploring priority areas for thermal energy network deployment.
- Streamline permitting, procurement, contracting and regulatory pathways.
- Quantify the impacts of thermal energy networks on the electric grid, on water and on usage of other fuels or energy.
- Improve community education and outreach.
- Address metering and billing questions.
- Scale the workforce for thermal energy network installation and operation.

In the final stage of *deployment*, a full regulatory framework will be necessary, which is the focus of much of the remainder of this report. As laid out above, the thermal energy network itself,

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[39] LeBel, M., Sandoval, R., Frick, N. M., & Deason, J. (2025). *Opportunities for integrating electric and gas planning.* Energy Analysis Division, Energy Markets and Planning Department. https://eta.lbl.gov/publications/opportunities-integrating-electric

similar to electric and gas distribution networks, should be considered a natural monopoly that should be subject to franchise rights and obligations, planning requirements and price regulation. These are the core aspects of modern utility regulation, although they do vary in important ways from state to state. In addition, the issues of quantifying and valuing electric grid impacts and integrated utility planning, across electric and gas utilities along with thermal energy networks, will be increasingly important over time. Eventually, broader questions about the future of energy services and utilities will likely need to be addressed as well. These are more speculative but discussed in section 6 below.

Progression through these stages relies on and therefore requires *data collection* and *transparency*. Owners and operators of thermal energy networks must be obligated to share as much relevant data as possible to accelerate learning and avoid making customers pay to repeat mistakes from utility to utility and from jurisdiction to jurisdiction. To address this need and to ensure that such data sharing uses consistent and therefore comparable metrics and measures, HEET has created a public thermal energy network databank that does not violate utility information sharing constraints, such as customer privacy.[40] A broad stakeholder process, including utilities, academic institutions and national labs, has informed the identification of (1) an essential data set; and (2) an enhanced data set of design parameters to foster learning, innovation and optimization through transparent information sharing. Categories of relevant data include, but are not limited to

- Thermal energy resource characteristics and performance.
- Thermal energy network system costs and customer usage patterns.
- Electric system capacity and planned upgrades.
- Gas system characteristics.
- Anticipated public work on roads and other infrastructure.
- Customer interest in new heating and cooling technology adoption.

The process of guiding a new technology from demonstration to development to scaling deployment is common and understood in the market economy. Doing so within a regulated industry requires some short-term adaptation and adjustment in traditional approaches to risk, prudence, and rate-making. Clear phases with clear learning goals will enable success.

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[40] HEET. (n.d.). *Geothermal network databank*. https://www.heet.org/databank. In 2024, Maryland passed a statute providing for thermal energy network pilots. This includes a requirement for gas utility pilots to provide standardized data to the HEET databank or other national research network. 7-1002(E)(2)(II). An Act Concerning Public Utilities — Thermal Energy Network Systems — Authorization and Establishment, Annotated Code of Maryland, Chapter 564 (2024). https://mgaleg.maryland.gov/2024RS/Chapters_noln/CH_564_hb0397e.pdf

4. System Planning, Design and Construction

Long before every uncertainty in thermal energy network regulation is resolved, regulators face the task of rationally evaluating proposed thermal energy network projects. A region's initial projects and the data collected from them are essential for the resolution of those remaining uncertainties, which adds a learning factor to the consideration and value of initial projects. There are four key dimensions of project design and initiation relevant to regulation: (1) site selection criteria, (2) network design, installation and resource acquisition, (3) customer acquisition and (4) safety and reliability guidelines.

A. Site Selection Requirements and Criteria

The following section attempts to distinguish between the universal elements of a project approval process, core requirements and additional selection criteria, which will vary depending on enabling statutory or regulatory language and other state regulatory mandates. The additional selection criteria can enable a ranking or weighting when choosing between a number of possible sites.

There are three core physical, economic and social requirements for any thermal energy network project to be successful, none of which typically create a large barrier to site selection. The first, physical feasibility, is an acknowledgment of the need for physical space for physical infrastructure. Availability of space in the street or other grant of location or right-of-way for the required thermal network distribution infrastructure, including distribution mains and service loops, is a requirement similar to other utilities such as gas, electric or water. The in-street infrastructure can be co-located with electric, gas or sewer infrastructure without hazard, increasing the opportunities in a dense urban streetscape, and can also occupy the grant of location formerly occupied by gas distribution pipe. Physical space for geothermal boreholes has more flexibility than often realized, given the increasing availability of drills that can drill inside basements and also directionally. Such space has included parking lots, parks, sidewalks, roads or even under building foundations or in high-rise pilings. Additionally, physical feasibility needs to consider any unusual physical challenges, such as existing large underground infrastructure, near-surface fossil fuel reservoirs or superfund sites, as such challenges may make the site cost prohibitive.

Second, economic or cost-effectiveness feasibility requires a density threshold for the geographical distribution of loads served and a scale threshold for the overall size of the project. The deployment of networked geothermal, akin to the gas system, requires a density of customers to make an interconnected utility supply preferable to non-utility or individual building solutions. While the exact density threshold is not yet fully quantified, an installation may remain cost effective at densities as low as 1,500 ft2 (140 m2) suburban homes on lots spaced 150 feet (about 46 meters) apart on a street.[41] The expected future density metric for thermal energy

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[41] Buro Happold engineering & HEET. (2019). *GeoMicroDistrict feasibility study*. https://www.burohappold.com/projects/geomicrodistrict-feasibility-study/ or

network deployment could be based on area of heated/cooled space or total load for a given linear distance. This initial density threshold does not necessarily overlap thermal energy network potential with existing gas territories, as many rural town centers may have sufficient density for a thermal energy network without having sufficient scale to justify service from a long-distance gas transmission pipeline. Regarding the thermal network scale threshold, the costs of the design, permitting, central pumping and utility control system are shared whether at a scale of tens or of thousands of buildings. Such an investment can be cost prohibitive if shared by a small number of low-load customers. As with the density threshold, this metric will not be fully quantified and verified until sufficiently different demonstration projects share their data.

The third social feasibility requirement is community interest and readiness. Given the novel nature of this utility service, the importance of community interest, education and engagement is magnified in the early stages from both local residents and government. This community-readiness metric is not intended to be a measure of up-front knowledge and buy-in but rather of sufficient openness or interest to indicate an opportunity for trust building, education and collaboration. Any thermal distribution utility will then need to prioritize and invest in the communities' knowledge and engagement throughout the project process. Readiness can be ascertained by a minimal combination of municipal support and the support of either interested "anchor tenants," such as schools or low-income housing authorities, or by the support and engagement of local community groups.

Given any project that meets sufficiently all three core requirements, there are many secondary site selection criteria for consideration, which may be significant in a given jurisdiction, as shown below in Table 1: for example, enabling legislation that directs projects to serve specific populations or regions or even regulatory direction to test deployment with particular types of buildings or loads, or streets with aging or constrained energy infrastructure. Outside of such policy-based criteria, there remain general site selection criteria that do impact project costs but do not necessarily make a project cost prohibitive or infeasible. This distinction acknowledges the complex relationship between the various project characteristics, the cost framework and the engineering approach. The importance of each is ranked to indicate how often this criterion is a key or driving factor. Although many assume that geology is a core and critical factor, for example, the actual distribution of appropriate geology for closed-loop, vertical borehole drilling indicates that this is rarely a limiting factor. Instead, this can usually be accounted for and adapted to in the engineering design. Additionally, the drilling cost per linear foot or meter, while a key project cost determinant, is far more variable by market (and available workforce) than by geology. Hence, the importance of geology is only medium.

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https://www.californiageo.org/wp-content/uploads/HEET-BH-GeoMicroDistrict-Final-Report.pdf

Table 1. Additional Site Selection Criteria[42]

Criteria	Description	Importance
Building Readiness	Age of buildings, maintenance (code violations, mold, asbestos and more), weatherization status and existing HVAC will all determine the time and cost to retrofit.	High
Customer Readiness	Customer interest will likely depend on the building transition necessary, the utility fee or rates, outreach, trust and desirability of other benefits such as central cooling.	High
Load Diversity	Seasonal, daily and hourly diversity of both heating and cooling load demand and of peaks improves the efficiency of the system, lowering cost of energy delivered and changing the thermal resource requirement. The building loads contain the first thermal resource — the buildings' thermal efficiency and the diversity of loads is the second thermal resource.	Medium
Additional Thermal Resources	Any needed boreholes and therefore their required space (vertical or deviated) can be reduced by identifying other thermal resources, such as sewer or wastewater exchange, industrial waste heat, solar thermal, water bodies, data centers, irrigation systems, swimming pools or snowmelt.	High
Geology	Depth to bedrock (shallow is better), type of bedrock (higher density is better) and conductivity of bedrock will all determine speed, extent and cost of drilling.	Medium
Hydrology	Groundwater improves conductivity, lowering boreholes needed; however, high flow raises drilling costs and may shift thermal strategy. For example, using mud rotary instead of air-hammer drilling can reduce groundwater production but extends drilling timelines impacting cost.	Medium
Permitting	Ideally, avoid any risks of state and municipal permitting issues or delays for boreholes and for construction. This includes environmental risks such as wetlands or areas that require remediation.	Medium
Energy System	Older or capacity constrained electric infrastructure may need upgrades or replacement, raising costs, and/or the avoided costs of electric or gas infrastructure replacement may improve economics.	High
Growth	Adding interconnecting ring infrastructure with reasonable density should be relatively easy to allow for utility growth.	Low
Other Local Criteria	The site serves a specific population and/or meets water savings, affordability, resilience, reliability or emissions goals.	Not applicable

The site selection process and criteria may also vary by the innovation phase. Demonstration projects often reasonably choose to minimize risks and to prioritize community readiness. Some

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[42] HEET. (n.d.). *Site selection initial checklist.* https://www.heet.org/geothermal-network-site-design-considerations

approaches to risk minimizing, such as building a smaller scale project, may actually decrease the likelihood of project cost effectiveness. Projects in the demonstration phase may not be required to meet any cost test but may still place additional weight on optimizing load diversity, other thermal resources or other methods of driving costs down in order to compensate for the expected higher, first-project, learning-curve costs. Development phase projects may also tactically prioritize a variety of project densities or populations or other factors in order to gather data to determine prudent scale, density and geography thresholds and resulting effective deployment plans. Coordinating this learning across regions would maximize ratepayer benefits. Finally, deployment phase projects may be strategically planned to seed network growth in areas with the highest avoided costs or other multidecade systemic energy system or population needs. Post deployment phase, when this infrastructure has reached a steady state in the way that our current electric and gas did in the past century, the incremental costs of adding customers or infrastructure may become very low, and the approach may again change; however, this stage is sufficiently far in the future that we do not consider it here.

B. Thermal Network Design, Installation and Resource Acquisition Considerations

Given a selected site and available thermal energy resources, the acquisition or contracting of necessary access or rights is a process still in development and will depend on resolution of ownership models and business models. Recommendations here are intended for the current demonstration and development phase where we are still learning and gathering the data needed to create a rational regulatory structure for our thermal energy system. It is exciting to consider the opportunity to create a thermal energy market with the distribution utility serving as the interconnecting and managing utility for diverse thermal energy assets. However, as we are currently in the learning phase, the authors recommend no prescribed or required separation of thermal asset and thermal distribution ownership and entities at this early stage. Instead, we consider here the practical considerations for exploring diverse ownership and acquisition approaches.

The fundamental need to install and maintain distribution pipe infrastructure in the streets replicates the precedent set by gas and water and other distribution utilities. Typically, grants of location are provided, for example, to a gas utility by the municipality. There are two key differences should the same utility wish to install a thermal energy network instead. First, the network pipes typically need to be at a sufficient depth, like a water pipe, to avoid freezing in a cold climate. It is of note that a shallow pipe depth will also impact thermal performance in a hot climate or a cold climate as the distribution pipe does provide some thermal exchange. Second, a thermal network pipe main or service does not need a setback from electric, gas or sewer infrastructure for safety reasons. However, given the potential for a small degree of thermal exchange, considering co-location with sewer or potable water should assess thermal impacts that may be beneficial. Aside from these considerations, the existing regulatory approaches from other utility services are reasonable to apply.

The contracting of access or rights for installation of closed-loop geothermal boreholes within the right-of-way or public spaces are a more novel consideration for utility regulators. This can be addressed through a number of approaches. A municipality or state, for example, can agree to host a borefield under a soccer field or park, providing access through a grant of location or right-of-way contract. A municipality or state could alternately own that thermal resource and contract to provide thermal energy to the local thermal energy network utility. Such exploration of various contracting arrangements should be encouraged in the learning phases as long as there is clarity around duration of the contract and operations and maintenance of the thermal energy resource. While a closed-loop vertical geothermal borehole is typically considered a 50-year asset, there is the expectation of the realistic used and useful life far exceeding 50 years, so such contracts must address any future transfer of ownership. Regardless of the borehole ownership model, the use of the ambient thermal energy in the bedrock may be considered a tapping of a thermal commons; this designation is under consideration in Massachusetts. A state grant of access to the thermal commons may have a requisite expectation or obligation to serve the public good or submit to thermal regulation. (See callout box in Section 3 for a discussion of this emerging concept.)

The contracting and acquisition of other thermal energy resources are similarly novel, though with some acknowledged precedent in the contracting for electric supply services and gas commodity. The ambient temperature range of the thermal energy network makes a very wide range of thermal resources useful. Traditionally called low-grade heat or ignored entirely, these resources (both sources and sinks) include sewer thermal exchange, water body thermal exchange, irrigation and snow melt thermal exchange and many types of industrial waste thermal. Additionally, buildings with unusual thermal or refrigeration loads, such as ice rinks, groceries, cold storage, laboratory space or data centers, are all excellent thermal resources. Finally, other district energy designs or forms of geothermal may also serve as contracted thermal resources.

The thermal utility may approach these resources in one of four ways. Some, such as buildings with countervailing thermal loads to typical seasonal usage, may be seen as customers that incidentally benefit the thermal balance. Alternately, buildings with significantly beneficial thermal loads may be metered and compensated as an independently owned thermal energy resource. Others, such as a water body thermal exchange, may be seen as an infrastructure investment akin to boreholes, owned by the utility as a firm supply. Finally, there are thermal resources that may be owned by, or invested in, by other entities and choose to contract with the thermal distribution utility. Such contracts may be fixed or intermittent; some resources may be used continuously, while others may be treated as peaking resources.

C. Customer Acquisition Process Recommendations

Given an approved thermal energy network site, there are two key aspects to customer acquisition: (1) outreach and education and (2) service agreements.

Given the current novel nature of this technology, the need for sustained investment in outreach in the demonstration and development phases is ongoing, and widespread educational efforts are critical. Given the centrality of community trust, several factors appear strongly linked with success in projects to date. First is establishing clear and declared channels of communication accessible to the wider community, not just those who have signed customer contracts or are physically impacted by the project. Informational and educational materials may include flyers, handouts and videos — all of which should use consistent and accessible language and images. Recommended communication channels include a webpage, newsletter, regular community presence and ongoing meetings and engagement and communication with municipal and other community leaders, including locally trusted organizations such as NGOs or faith-based organizations or schools. Second is the identification of dedicated personnel as community liaison throughout the course of the project. Consistency of personnel filling this outreach role creates communication continuity, builds the personnel's understanding and also builds community trust. This outreach lays the groundwork for customer recruitment: a conventional sales team knocking door to door for buildings located along the expected infrastructure. Such an effort in an existing utility is based on a universal understanding of the legitimacy and existence of those energy systems, hence the necessary education phase for this novel system. Outside of marketing materials, early projects have found letters of support from the municipality and other diverse entities, such as local NGOs, to be helpful in building trust with potential customers. Signing an initial statement of interest can engage the customer in ongoing education without requiring them to make a commitment. Collaborative community meetings with technical experts, service providers, community members and other stakeholders provide a forum for presenting accessible information and giving sufficient time to answer all questions that arise, again demystifying the novelty.

Individuals enlisted to engage in a demonstration phase project will likely pay participation fees that are token or nominal as an incentive for participation and as a method for establishing a new billing relationship. A demonstration or development phase project should also include data-sharing permissions as needed to ensure that research data on the system performance is shareable, as this information is a key value of the investment.

All of this prepares the way for a service agreement. A project in the development or deployment phase in a state with statutory permission for thermal utilities and an initial approved rate will have a service agreement more akin to a standard gas service agreement. A demonstration phase project, however, may set a pilot duration time, after which the customer may either choose to restore their original service or switch to the new technology, with the participation fee potentially shifting to a rate or other fee. Such a pilot service agreement must clarify the utility's commitment to maintaining the infrastructure for the customer and what recourse the customer has should the utility decide not to continue service.

While service agreement approval from regulators allows formal customer acquisition, the success of that customer acquisition requires potential customers to already have a growing relationship and growing knowledge when they meet to sign the service agreement. In other words, the novelty of the service requires investing in broad community education.

D. Safety and System Reliability Guidelines

All design, installation, testing and operation of geothermal energy networks should adhere to the best available standards and code where applicable. Given the novelty of this infrastructure design, it must primarily draw on established standards and code related to building HVAC, water pipelines and geothermal heat pumps. Recommendations specific to the interconnection of these components, as in a thermal energy network, are included for the first time in the 2025 release of the Canada/U.S. standards CSA/ANSI/IGSHPA C448,[43] under the title C448.3 Planning, Design, Installation and Commissioning of District Energy Systems. The first state utility commission guidelines on geothermal networks were released in 2024 by the pipeline safety division of the Massachusetts DPU, titled "Networked Geothermal Safety Guidelines."[44] These guidelines cite both CSA/ANSI C448 and ASTM F2164, a standard for field-testing of polyethylene piping.

Safety guidelines specific to an ambient temperature thermal network reflect a narrower set of risks than for an energy system that utilizes explosive fuel or high voltage power or high temperature steam or hot water. The primary safety risks for workers are in the use of heavy equipment during construction and in underground repair work. Worker safety while using heavy equipment and working underground are well-established fields to which this document has nothing to add except to comment on its importance. The primary safety risk to the customer is a loss of service at a time when heating or cooling is necessary for health and well-being. Regarding safety related to reliability, the following actions can be considered:

- Regulators of geothermal networks may, as Massachusetts did, request a worker qualification plan for all tasks related to the integrity of the system to ensure trained and skilled workforce on critical tasks.

- Regulators may lay out clear documentation and record-keeping requirements for design, construction and operations, as well as specific requirements for any incidents, such as third-party hits, leaks or outages.

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[43] Design and Installation of ground source heat pump systems for commercial and residential buildings. CSA/ANSI/IGSHPA C448 Series 2025, https://webstore.ansi.org/standards/csa/csaansiigshpac448series2025

[44] Memorandum on Networked Geothermal Safety Guidelines. (July 31, 2024). Massachusetts Department of Public Utilities. https://www.mass.gov/doc/dpu-networked-geothermal-guidelines/download

- Regarding engineering documents, review and stamp by a professional engineer certified by the International Ground Source Heat Pump Association (IGSHPA) to design geothermal heat pump systems is recommended.
- Regarding records of infrastructure, use of geocoding and/or tracing wire may be considered as best practice for underground infrastructure, with an expected life span well over 50 years.
- Regulators can include geothermal networks in their existing requirements for energy distribution companies regarding emergency preparation and restoration of service.

This infrastructure has several unique considerations relevant to a discussion on restoration of service and reliability. First, there is a lag time in impact to the customer's thermal provision should a thermal main or thermal resource be compromised. The heat pump in the building can continue to heat or cool, though less efficiently, for hours as the supply temperature or flow changes or ceases. This provides a time window for repair without interruption of service. Second, the interconnected bidirectional ring design of thermal networks avoids the single-point failure vulnerability of a traditional energy distribution system. A catastrophic failure in one building or one block's thermal main can be isolated and does not cascade to neighboring streets and mains. The buildings and thermal main loops can each be "islandable," a form of resilience. Proper and accessible valves and shutoffs are required to ensure islandability. The islandability resilience feature can be maximized by requiring battery backup or other on-site generation for the electricity needed for pumping. Additionally, those neighboring streets and mains may even be able to provide short-term resilience during an outage or failure. Lastly, there must be sufficient electric capacity, both at the local distribution system and broader system resource adequacy level, for the new electric load as a result of the new customer installations.[45]

Safety and permitting considerations for thermal resources such as boreholes is an area that needs increased standardization. The regulation of geothermal boreholes currently varies widely by state and is commonly overseen either by environmental departments concerned about protecting the water supply or by energy departments. There exists in many states a conflation or confusion of geothermal boreholes by technology type. Clarification of the direct relevance of existing state regulation should begin with a clear separation of the deeper and direct-use geothermal technologies from the shallow ambient technologies used for thermal energy networks and considered here. Additionally, the geothermal energy network has been consistently proposed, including by HEET in the first statewide feasibility study, to use closed-loop rather than open-loop vertical boreholes as a standard baseload thermal technology.[46] This removes any direct contact or interaction with the water table after construction and simplifies necessary regulation, including regulatory setbacks from wells or other water bodies or resources.

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[45] Many heat pumps come preequipped with electric resistance heating backup. As a technical matter, such capabilities can be shut off as unnecessary since equipment connected to a thermal energy network does not suffer degraded operational efficiency during cold winter outdoor temperatures. Planning for the electric capacity to accommodate the load of the relevant electric resistance heating backup units would likely lead to unnecessary investments and expenses as well.

[46] Buro Happold engineering & HEET, 2019.

For the construction phase of a geothermal borehole, it should be noted some boreholes will have rates of water production or the flow of water out of the borehole during drilling. This flow is more likely to occur in high water table geologies, resulting in different cost impacts and is typically larger in air-hammer drilling and somewhat mitigated via mud rotary drilling approaches. Best practices and guidelines on bit and drilling technology choices are in development at the newly formed Geothermal Drilling Association (GDA), which is working in collaboration with IGSHPA. The intersection with water regulation is often further confused by the use of the word “well” instead of “borehole.” This language choice varies between states, and we recommend avoiding the use of the word “well” for closed-loop geothermal exchange infrastructure.

Regarding safety and permitting of other thermal energy resources, a full consideration is beyond the scope of this report. However, as awareness and adoption of diverse thermal resources for ambient temperature distribution increases, there is more attention being given to best practices and guidelines. For example, 2025 CSA/ANSI C448 now includes a new section called “Design and installation of ground source heat pump systems connected to energy foundations” (in other words, thermal exchange built into the pilings of tall buildings), as well as an annex on the design and installation of wastewater energy transfer systems.

Given the emerging nature of this technology, data collection and sharing, as well as regular review and updates of all guidance and recommendations, are strongly recommended.

5. Costs, Revenue and Rate-making

Given the recommendation that thermal energy networks be treated as monopolies, it makes sense to ground rate-making considerations in general principles applicable to other regulated utilities. Here, we examine how to translate traditional practices into the novel structure of a TEN, recognizing that the appropriate strategy will evolve as TENs mature. In the initial demonstration phases of thermal energy networks, simpler rate-making procedures are likely warranted. Where an incumbent utility is expanding service to include TENs, that utility could record the costs for pilot or demonstration projects in its research, development and demonstration account under the applicable Uniform System of Accounts. For example, FERC's Gas Uniform System of Accounts authorizes gas utilities to include "research, development, and demonstration" costs that are "reasonably related to the existing or future utility business, broadly defined, of the public utility or licensee or in the environment in which it operates or expects to operate."[47] As noted, TENs may be a viable "future utility business" for gas companies, particularly if their expected future operating environment involves a transition away from traditional gas service. Given this purpose at an early stage, it may be reasonable to place a portion of cost responsibility on gas customers in a simple and straightforward way.[48]

Generally, and in the longer term, if thermal energy networks are subject to economic regulation by utility commissions, most, if not all, of the costs of the thermal energy network should be recovered from the customers of that network. In the regulation of customer prices for utility service, the prevailing practice is to develop separate tariffs for a small and easily identifiable number of customer classes. These tariffs contain both rates (prices) as well as other terms and conditions for service. The rates are typically the same for each customer within a class regardless of the customer's location within a service territory,[49] a practice known as postage stamp pricing. This is done for administrative simplicity but also has deep links to the principles of fairness and nondiscrimination across customers.

Analytically, the final rates for customers tend to be developed in three high-level steps: (1) determination of the annual revenue requirement, (2) allocation of costs between customer classes and (3) final design of the retail rates. For each step, data collection and tracking — with respect to utility costs of all kinds, energy resources and customer characteristics, usage and behavior — is an important foundational element of rate-making. A simplified diagram of rate-making for an investor-owned thermal energy network is shown in Figure 4 below. The remainder of section 6 explains these three steps and key decision points going forward, each of which is subject to regulatory oversight and approval for investor-owned utilities.

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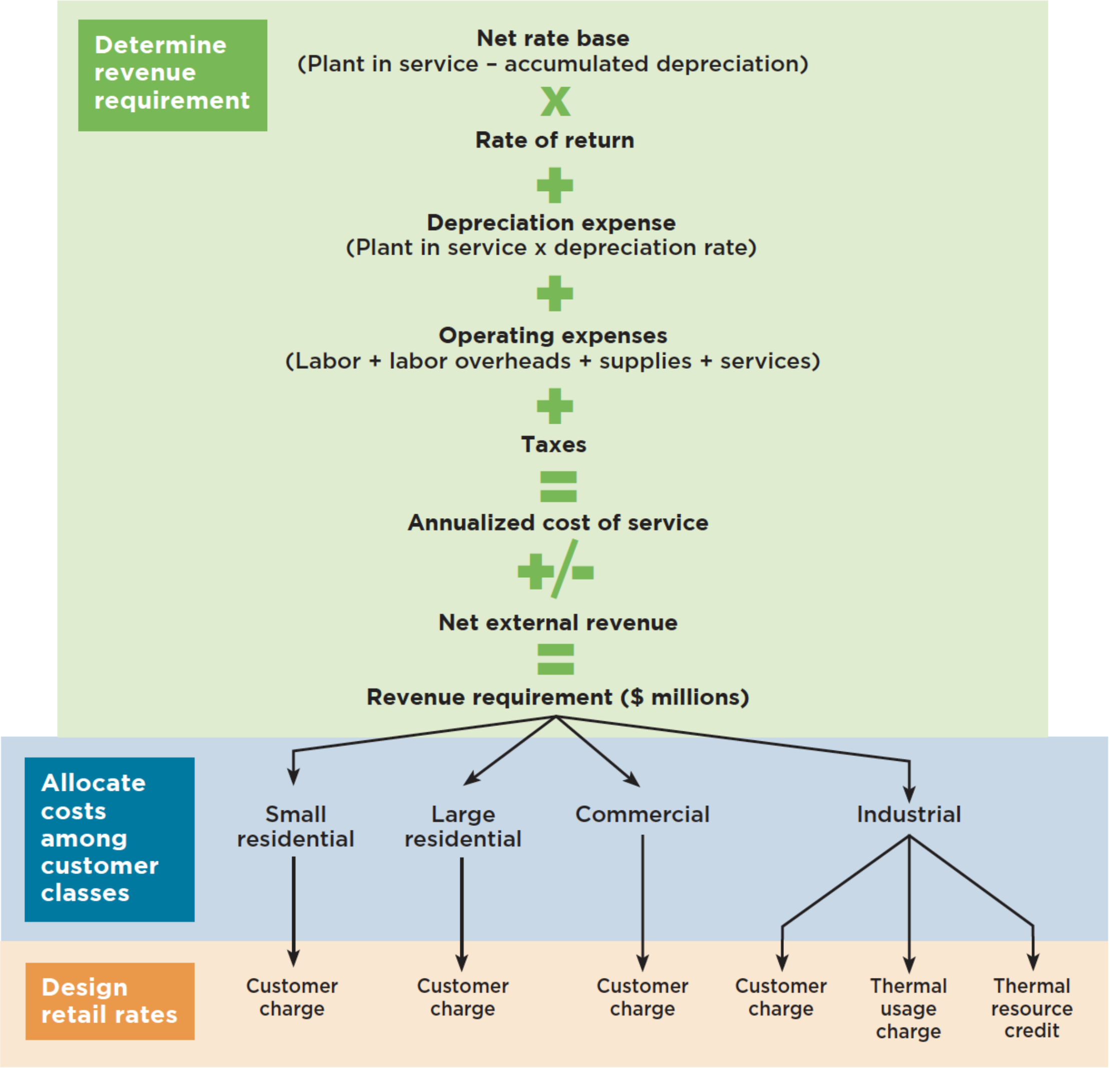
[47] See 18 C.F.R. Part 201.32.B. The Electric Uniform System of Accounts includes a similar definition of research, development and demonstration expenses: 18 C.F.R., Part 101.32.B.

[48] For learning purposes and future cost recovery structures, detailed cost data should be tracked, recorded and ideally shared. However, in advance of the establishment of a formal uniform system of accounts for thermal energy networks, this may be preliminary and used in a simplified way for rate-making.

[49] While rates are generally uniform for all customers in a class, the initiation of utility service and connection of a customer to the system is subject to line extension policies, and an economic analysis of whether a contribution in aid of construction is necessary for new customers.

Figure 6. Simplified Rate-making Process for Investor-owned Thermal Energy Networks



A. Revenue Requirement and Cost Accounting

The annual revenue requirement is the overall amount of revenue that is designed to be recovered through customer rates in a given year. The most likely scenario would be the adoption of the cost-of-service rate-making paradigm used by other utility services in the United States. Cost-of-service rate-making, while not perfect, balances several important policy goals: providing sufficient revenue for the owner-operator to provide safe and reliable service while keeping rates as affordable as possible for ratepayers. In the context of other utility services, principally electric but also gas, performance-based rate-making (PBR) has been an effort to build on cost-of-service rate-making structures and improve some of its inherent weaknesses.[50]

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[50] See Lebel, M., Shipley, J. Kihm, S., Calice, M., & Cappers, P. (2023). *Improving performance incentives in the United States: A policy, legal and financial framework for utility business model reform.* Regulatory Assistance Project, https://www.raponline.org/knowledge-center/improving-utility-performance-incentives-in-the-united-states-a-policy-legal-and-financial-framework-for-utility-business-model-reform/

Many of the same PBR innovations can be applied to thermal energy network regulation and rate-making, starting with multiyear rate plans and extending to decoupling and outcome-based incentives for reliability and customer service.

As denoted by the phrase “cost-of-service” rate-making, the starting point for the annual revenue requirement is the calculation of the annualized cost of service.[51] Cost of service is a technical term, and for investor-owned utilities, it typically includes operating expenses, depreciation expense (a measure of the annual loss in value of utility capital assets) and taxes, as well as an explicit element for a rate of return on net rate base. For municipal utilities or cooperatives discussed in part B of section 3, there are two key distinctions. First, because these entities are typically tax exempt, there are no taxes. Second, since there are no shareholders, there is no need to consider a return on equity investment. Instead, these entities typically have defined commitments to make bond payments but also must include sufficient room in their revenue projections to ensure that financial obligations are met across the board, which is often defined as a debt service coverage ratio.

Cost tracking, accounting and financial reporting are all foundational to modern utility regulation in general, as well as the calculation of the cost of service more specifically. To keep track of their costs in a way that is simple enough for regulators to review, utilities are typically required to follow a Uniform System of Accounts applicable to their service type. FERC maintains the Uniform System of Accounts for gas[52] and electric[53] utilities. Many states provide systems of accounts for water[54] and sometimes steam utilities.[55] To the authors’ knowledge, no state has yet adopted a Uniform System of Accounts specific to thermal energy networks but could straightforwardly adapt one from either the federal gas Uniform System of Accounts or a state water Uniform System of Accounts. In either case, changes will be necessary to reasonably describe the key aspects of the investments necessary for a thermal energy network system as well as relevant expenses. The two major types of costs that will need amendment are known as plant accounts, which record the cost of assets owned by the utility, and operation and maintenance expense accounts, which record annually recurring expenses. Key details are displayed in Table 2.

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[51] See chapter 8 of Lazar, J. (2016). *Electricity regulation in the US: A guide*, 2nd ed. Regulatory Assistance Project. https://www.raponline.org/wp-content/uploads/2023/09/rap-lazar-electricity-regulation-US-june-2016.pdf

[52] See 18 C.F.R. Part 201 (Uniform System of Accounts Prescribed for Natural Gas Companies Subject to the Provisions of the Natural Gas Act).

[53] See 18 C.F.R. Part 101 (Uniform System of Accounts Prescribed for Public Utilities and Licensees Subject to the Provisions of the Federal Power Act).

[54] The National Association of Regulatory Utility Commissions (NARUC) publishes a uniform system of accounts model for water utilities that states may consider: NARUC. (2025). *Uniform system of accounts for water utilities*. https://maxxwww.naruc.org/forms/store/ProductFormPublic/usoa-water. States may adopt the NARUC model or develop a standalone version. See, for example, 220 Code Mass. Reg. § 52.00 Uniform System of Accounts for Water Companies (establishing a state-specific version); and Okla. Admin. Code title 165, chapter 65, 165:65-9-10 (a) (directing water utilities to adopt the applicable “Uniform System of Accounts” published by NARUC or another system acceptable to the Public Utility Division of the Oklahoma Corporation Commission).

[55] For example, while New York requires steam utilities to utilize a specified system of accounts, Massachusetts only regulates steam utilities for safety, not accounting or rates. Compare 16 N.Y. Comp. Codes Rules & Regs. § 460.0 (prescribing a uniform system of accounts for steam utilities) with 220 Code Mass. Reg. § 20.01 (limiting oversight of steam utilities to safety requirements) and 220 Code Mass. Reg. §§ 50.00, 51.00, 52.00 (providing uniform systems of accounts for gas, electric and water companies).

Table 2. Major Cost Accounting Categories for Thermal Energy Networks

	Category	**Detail**
Utility Plant	Utility-owned thermal resources and rights	Exploration and drilling costs for geothermal resources (labor and equipment), materials and/or access rights (as applicable)
	Network assets	Pipes (including labor, materials and other installation costs), pumping equipment and controls, supplemental temperature control equipment (e.g., boilers and cooling towers), system control enclosures and system monitoring
	Service loops and customer meters	
Operation and Maintenance Expenses	Ongoing labor and maintenance costs	
	Electricity and water supply costs	
	Thermal energy resource payments and credits	Costs to obtain non-utility thermal energy resources (e.g., industrial waste heat) to support the network

In the initial stages of demonstration and development, costs may be different in certain ways. In the demonstration phase, there should be an emphasis on system monitoring and other data collection for research purposes, and it is uncertain at present which aspects of those efforts should continue as knowledge about these systems matures. In addition, behind-the-meter equipment, which is typically customer owned, could be funded by the utility in early projects and ultimately paid for through customer rates. For example, Eversource paid for heat pump equipment, duct work and weatherization for customer buildings in its Framingham pilot, and these costs were recovered as part of overall pilot costs.[56]

While it is often simpler to present the annual revenue requirement as equal to the annualized cost of service, the revenue that needs to be included in recurring rates for customers is always net of other financial payments made to or by the utility. While this is sometimes very modest, in the context of potentially combined utility structures, it may take on a new level of importance.[57] For example, a fully integrated "pipes" utility that owns both gas assets and a thermal energy network in a given area would have an initial step where the cost of both systems, as well as a range of administrative and general costs, would have to be split between the customers of the two systems. In the initial stages of this relationship, when thermal energy networks are in the demonstration and development stage, it may be reasonable to place some thermal energy network costs on existing gas customers. This can be characterized as a revenue requirement that is lower than the calculated annualized cost of service for the thermal energy network, as shown by the formula in Figure 6 above with the category of "net external revenue." Furthermore, if the gas utility has a clean heat or GHG emission reduction obligation, it may be appropriate to include TEN-related costs in gas rates as part of meeting that obligation — just as the gas utility might pay for heat pump incentives or weatherization costs in gas rates. Similarly, while not shown in Figure 6, the revenue requirement also includes net financial incentives or penalties, whether due to outcome-based performance incentives under PBR or derived from other regulatory initiatives.

B. Cost Allocation and Rate Design

In the process of setting the rate structure — a term that combines the cost allocation and rate design steps — regulators and stakeholders refer to a wide range of principles or objectives, many lists of which have been compiled by past analysts.[58] Many of these principles are still useful today, though it is also worth asking how changing circumstances may affect them. Some generally accepted objectives that remain helpful in today's debates regarding rate structure include:

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[56] Eversource paid for these expenditures in the Framingham pilot but recognized that it would not do so for any future TENs applications. Conner, P. M., & Goldman, M. (2019, November 8). *Direct testimony of Penelope Mclean Conner and Michael Goldman*. Commonwealth of Massachusetts, Department of Public Utilities. Eversource Energy, DPU 19-120, Exhibit ES-PMC/MRG-1. https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/11419982.

[57] There are many reasons why the revenue requirement may deviate from the specific annualized cost of service calculation. Multiyear rate plans and formula rates are adjusted from the calculated cost of service in specific ways. Performance incentives and penalties are growing in popularity as well and are not a cost of service in the traditional sense.

[58] The most famous of these are the Bonbright principles from Bonbright, J. C. (1961). *Principles of public utility rates.* Columbia University Press. https://www.raponline.org/knowledge-center/principles-of-public-utility-rates/. On page 291, Bonbright lists eight frequently cited principles but immediately explains that "lists of this nature are useful in reminding the rate maker of considerations that might otherwise escape his attention, and also useful in suggesting one important reason why problems of practical rate design do not readily yield to 'scientific' principles of optimum pricing. But they are unqualified to serve as a base on which to build these principles because of their ambiguities … their overlapping character, and their failure to offer any rules of priority in the event of conflict." He goes on to discuss his preferred three criteria of "(a) the revenue-requirement or financial-need objective … (b) the fair-cost-apportionment objective … and (c) the optimum-use or consumer-rationing objective" (p. 292).

- **Effectiveness in yielding total revenue requirements.** The utility should expect to recover its revenue requirement from customer rates, with a reasonable amount of stability from year to year. Other rate-making features besides rate designs and levels are relevant here, notably revenue decoupling.
- **Customer understanding and acceptance.** Prices should not be so complex or convoluted that customers cannot understand how their bills are determined or how they should respond to manage their bills. Customers and the rest of the public should generally accept that the prices customers are charged are fair for the service they are receiving.
- **Equitable allocation of costs and the avoidance of undue discrimination.** The apportionment of total costs of service among the different customers should be done fairly and equitably.
- **Efficient price signals that encourage optimal customer behavior.** On a forward-looking basis, prices should encourage customers to use the energy network and resources in ways that are economically efficient.

There are two preliminary issues before major cost allocation and rate design decisions can be made: (1) the availability of relevant data on customers and their usage patterns, system characteristics and operation and costs; and (2) the definitions of the relevant customer classes and subclasses. For long-standing utilities, there are historical practices to build upon here. These historical practices make it easy to depict cost allocation as two sequential steps, but there are significant feedback loops between those two steps that are important to consider in this new context.

Understanding the historical context and development for other regulated utilities provides some perspective. For most of the 20th century, electric utilities had simple monitoring devices on transmission and distribution infrastructure and, to different degrees, moderately more complex monitoring of generation facilities. Electric meters for customers could register only kWh consumption for small customers, and both kWh consumption and kW demand measurements for large customers. In many cases, utilities would supplement this with load sampling — more granular metering and data collection on a limited number of sample customers to better understand usage patterns. In the 21st century, the amount of data available to electric utilities has skyrocketed with advanced metering and sophisticated monitoring devices now common for every part of the electric system. But this earlier historical stage of data collection and customer metering shaped both cost allocation and rate design in important ways. Similarly, residential, commercial and industrial customer classes were defined long ago, although the details varied from jurisdiction to jurisdiction, and have been updated over time, usually very slowly.

In the context of a new utility system and offering, we are starting with more of a blank slate. There are significant questions about the correct type of system monitoring and customer metering for thermal energy networks. Key questions about the cost of the relevant devices as well as their value remain unanswered. In the demonstration phase, additional monitoring and data collection can be justified as key to resolving questions about system design and operation, with the subsequent evolution to be determined. Individual customer metering has been installed for many types of district energy systems across the world.[59] For thermal energy networks, the Blatchford Renewable Energy municipal utility in Edmonton, Canada, has installed individual customer metering to enable variable rates for all customers.[60]

However, relatively sophisticated customer metering for thermal energy networks — measuring the flow of water and input and output temperatures on a frequent and granular basis — appears to be currently quite expensive in the United States. It should not be taken as a given that every customer should receive a meter if that would be prohibitively expensive. In the electric context, streetlights are frequently an unmetered load because having a meter at each streetlight connection point would be very expensive. Furthermore, the value of the information gained would be low because streetlight usage patterns and levels tend to be straightforward for a given lighting type and number of lights. It may be the same initially for some types of thermal energy network customers, although this would become less true over time if metering costs fall.

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[59] This includes the HOFOR district energy system in Denmark (https://www.hofor.dk/erhverv/priser-paa-forsyninger-erhvervskunder/prisen-for-fjernvarme-2025-for-erhvervskunder/) and the False Creek Neighbourhood Energy Utility in Vancouver, Canada (https://vancouver.ca/home-property-development/metered-rates.aspx).

[60] Blatchford Renewable Energy. (2026). *2026 rates.* https://blatchfordutility.ca/2026-rates-blatchford-renewable-energy/

Customer Metering Options for a Thermal Energy Network Utility

Directly attached to utility system

- Gallon flow metering: This system is identical to metering used by water utilities. For some customers, there may be a linkage between the operation of heat pump equipment and the volume of water flowing through the service loop and the usage of thermal energy by customer.
- Thermal energy metering: This requires temperature sensors on both the inflow and outflow sides of the service loop, as well as a flow measurement meter. Temperature sensors can gauge the temperature differential between the inflow water and outflow water to understand whether that customer is heating or cooling and the magnitude of the temperature changes. In the case of ambient-temperature thermal energy networks, sophisticated sensors are needed to measure accurately the small difference between inflow and outflow temperatures associated with the heat pump operation of most customers. The units for such metering can measure BTUs (British thermal units), joules or kWh. Setting kWh as standard units for this technology can significantly improve understanding of comparability between energy choices and make integrated planning and grid benefit valuation simpler.

Not directly attached to utility system

- Equipment operation metering: The run-time of the customer heat pump may be reasonably linked to the amount of thermal energy exchanged between the customer and the thermal carrier.
- In-unit temperature metering: The temperature set point or actual temperature within a building may be reasonably linked to the amount of thermal energy exchanged between the customer and the thermal carrier. Such internal monitoring may be considered more intrusive than other options.

For the near term, it may be reasonable to decide that small thermal energy network customers have no required metering at all, although the simpler and less expensive metering options could be explored to see if they can be used as reasonable proxies. If individual customer metering is not installed or a simpler metering option is chosen, it may be a beneficial practice for utilities to select a limited number of customers for load sampling with advanced thermal metering, as was done historically for electric utilities. The data collected from load sample customers can be used to create reasonable approximations for different types of customers in the aggregate. Such approximations can be quite useful for system planning and operation as well as cost allocation. Of course, this still means that rate design and billing options are quite limited for customer classes without sophisticated individual customer meters.

Now, this brings us back to allocation of costs across customer classes. With a limited amount of system and customer data, it is our goal to fairly and efficiently divide up the revenue requirement among a limited number of easily identifiable customer classes.[61] There are two primary conceptual principles that help guide the way to the right answers:

1. Cost causation: Why were the costs incurred?
2. Costs follow benefits: Who benefits?

While full answers to these questions will require study, system planning and operational characteristics point the way at the initial stage. For example, many network customers will have a dedicated service loop but others — for example, customers in multifamily buildings or shared office buildings — share a service loop. In addition, the overall level and mix of thermal resources necessary for the network will likely be driven by system peak constraints, which could be in the summer, winter or a mix of both. Different class contributions to those broad system peaks should be appropriately reflected in the cost allocation process.

Now we can consider both cost allocation and rate design jointly. We can start with residential customers. For example, a 1,000-square-foot apartment and a 5,000-square-foot single-family home should have different levels of cost responsibility for a proportionally different set of heating and cooling needs. The apartment shares a service loop and likely has modest impact on peak. The large single-family home has a dedicated service loop and a proportionally bigger impact on peak. In the electric context, this type of differing cost responsibility was traditionally accomplished through kWh metering and kWh rates. If individual customer metering is installed, variable thermal energy rates can be implemented. However, without individual customer metering for thermal energy networks, such rates are not possible.[62]

There are two different potential methods for charging these two different thermal energy network customers different bills. The first is creating at least two separate residential customer classes. The difficulty is coming up with reasonable dividing lines between different types of residential customers using reasonably available distinctions. One potential distinction is single family and multifamily. However, square footage of heated or cooled space or other metrics may be viable in certain circumstances as well. While these types of considerations may seem unusual for residential customers, these types of decisions have always been made to develop distinctions between different types of commercial and industrial customer classes. Alternatively, customer classes could be kept broad and cost distinctions reflected in tiered customer charges. The considerations for defining tiers could be similar to the potential customer class distinctions. For example, specific rates could be designed to charge per square foot of heated or cooled space or per unit of nameplate capacity for customer equipment. Of course, these two strategies — multiple residential customer classes and tiered customer charges — can be combined. There can be two residential customer classes, each with tiered customer charges, but this may test the limits of acceptable complexity. As may be evident, this is why cost allocation and rate

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[61] See generally Lazar, J. (2020). *Electric cost allocation for a new era: A manual.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/electric-cost-allocation-new-era/

[62] Other means of encouraging efficient customer equipment and operation should be explored. This could include incentives for weatherization and certain equipment characteristics as well as demand response or direct load control programs.

design should be considered jointly. There are usually several different methods for accomplishing similar objectives.

For industrial customers, there is a different mix of considerations. In addition to the fair and efficient division of costs, we would like to attract low-cost thermal resources to connect to the system. This is likely an important part of driving down overall thermal energy network costs to become competitive with other energy sources and systems. It is this need to provide appropriate compensation for value to industrial customers as well as potential significant differences in system impacts that could justify more expensive metering for industrial customers. Sophisticated thermal metering would allow for, at a minimum, two separate types of rates for industrial customers: a thermal usage charge for times when that customer is leaning on the system (e.g., taking heat in the winter) and a thermal resource credit for times when that customer is supporting the system (e.g., providing heat in the winter).

Eversource Proposal for Geothermal Service Rates for New Construction

In September 2025, Eversource affiliate NSTAR Gas Company (NSTAR Gas) petitioned the Massachusetts Department of Public Utilities to approve a regulatory and rate-making framework for new construction customers taking “networked geothermal services” from NSTAR Gas (DPU Docket 25-86). The proposal includes four customer classes for geothermal services, which parallel four existing gas customer classes. While the residential customer class would continue to be based on the customer type, the C&I customer classes would be distinguished differently. Gas C&I customer classes are distinguished based on therms of annual usage, but the geothermal customer classes would be distinguished based on equipment size denominated in tons of connected capacity. For each rate class, NSTAR Gas proposed a monthly customer charge and set of charges based on the customer’s equipment size, denominated in dollars per ton of connected capacity. This would reflect the fact that customers with different equipment use the system to different extents. Such a rate design is generally in the nature of a tiered customer charge since customers will not be able to influence the billing determinant after their equipment is installed. There would be no individual metering for any customer class. NSTAR Gas is also proposing that existing gas customers cover part of the costs of new geothermal network installations and pegs the level of the geothermal service rates through a comparison with the cost of equivalent gas service to the new customers.

6. Broader Issues for the Future of Utility Regulation

The preceding sections have identified options and considerations for the regulation of thermal energy networks. These issues are all critical topics for energy systems providing essential public services, especially when they are imbued with natural monopoly characteristics. In this section, we consider a set of more complex questions. How should the regulation of thermal energy networks, gas networks and the electric grid all be coordinated? And what is the future of each network? Does it make sense for society to support all three in a particular area? Should ownership structures for energy services and even behind-the-meter customer equipment be rethought?

Utility regulation has always been a balancing act among competing goals, many of which are described in section 3. As policymakers consider the rules of the road for modernizing thermal services, they will need to decide which of these goals is most important and which can be moderated, recast or viewed as secondary. Two of these goals — ensuring safe and reliable service and continuing to provide heating and cooling services through at least one service option — will likely be viewed as essential in all cases. Meanwhile, if a major purpose of thermal energy networks is the reduction of GHG emissions, in many instances they will be designed to reduce gas sales and customer count, which will put pressure on gas utility revenues. If reducing GHG emissions from gas utility customers is a high-level public policy objective, that goal will provide a major organizing principle for the regulatory transition.[63] Other jurisdictions may prioritize energy security, energy independence, resilience, safety and affordability, all of which can be supported by thermal energy network service. As a practical matter, each jurisdiction will need to balance its objectives and manage trade-offs.

Traditional regulation typically treated individual utility services in isolation, setting the prices and conducting planning for each separately. This is largely true even for combined electric and gas utilities, although many combined utilities provide a single bill to an individual customer for both gas and electricity. This means that these separate systems have always been in competition with each other in some ways. Competing electric and gas versions of similar technologies (e.g., clothes dryers, ranges, water heaters) have existed on the open market for quite some time, and customers can choose whichever they prefer, which may depend on the relative prices of the two energy options as well as the price and customer preferences of the different appliance technologies. For space heating, many customers have long been able to choose from several different options, including furnaces and boilers that use gas delivered by utilities, propane and heating oil technologies and wood or biomass in some regions. Historically, electric space heating technologies were somewhat limited, with inefficient electric resistance heating being common in many parts of the country. In the last few decades, air-source heat pumps have

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[63] Anderson, M., LeBel, M., & Dupuy, M. (2021, May). *Under pressure: Gas utility regulation for a time of transition.* Regulatory Assistance Project. https://www.raponline.org/toolkit/under-pressure-gas-utility-regulation/

become popular for cooling and heating needs in the warmer parts of the United States. However, recent developments for cold-climate heat pumps and initiatives to spur the adoption of efficient electric heating provide some new motivations for integrated planning between electric and gas utilities.[64] In this context, thermal energy networks, as a neighborhood or community scale option to convert customers from gas to efficient electric heating, may supercharge this need for integrated planning. Thermal energy networks serve as a significant *efficiency* option for electricity, compared to air-source heat pumps, as well as an alternative to gas for heating, which means that all three should be considered simultaneously.

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[64] LeBel et al., 2025. This growing overlap raises questions about whether the natural monopoly should be considered “energy services” rather than “gas” or “electric” services separately. If so, allowing multiple overlapping systems to provide that “energy service” risks creating “wasteful duplication” that undermines the rationale for granting a monopoly in the first place. A recent report from Stanford’s Climate and Energy Policy Program describes these “wasteful duplication” risks in more detail. Lappen, J., Wara, M., Mastrandrea, M., & Zerbe, A. (2024, September). *The unseen competition in the energy transition: Acknowledging and addressing inter-utility competition to achieve managed decarbonization.* Stanford Climate & Energy Policy Program: Woods Institute for the Environment. https://woods.stanford.edu/sites/woods/files/media/file/woods-energy-transition-white-paper-v06-web.pdf

The Evolution of the Obligation to Serve

As discussed in section 3, requiring a utility to provide essential services to all customers within its service territory (the obligation to serve) is a core tenet of utility policy. Which services are essential can and should evolve alongside technology and society. Such an evolution could lead to at least two different outcomes. First, an incumbent may remain the service provider, but the nature of the service may shift. For instance, many cities and investor-owned utilities transitioned from offering gas streetlamp services to providing electricity for streetlights in the 1940s and 1950s.[65] While the nature of service changed, streetlights remained networked services offered by a single provider.

Second, technology may evolve so much that an incumbent's obligation to serve is removed entirely. As telecommunications and information technology developed, telephone services shifted from landline based to mobile and internet based. Wireless technology also undermined the need for a single set of wires, and a wide variety of new entrants were often better positioned to provide service than incumbents. As a result, telephone companies are no longer obligated to maintain landline networks. The Federal Communications Commission noted those obligations were "trapping incumbent [local telephone companies] into preserving outdated technologies and services at the cost of a slower transition to next-generation networks and services that benefit American consumers and businesses."[66] Due to their lack of utilization and high costs, the FCC concluded continuing to maintain the old landline (copper) networks was no longer in the public interest.

Gas networks may soon face a similar decision point. With electric utilities increasingly providing heating services, the utilization of gas for heating will decline, and the cost of maintaining an extensive gas distribution network may become unreasonable. The obligation to serve may evolve into an obligation to provide heating service — through gas, electric or thermal networks. This could enable a gas utility to evolve its business, continuing to offer heating services via thermal energy networks. Or the gas utility's obligation to serve may dissipate entirely, leaving the field to electric and new thermal energy network providers. The exact outcome in any given neighborhood will vary, as highlighted in this section. Change is coming, but many questions remain about how, where and when it will manifest. This all needs to be done in a manner where all customers continue to have affordable access to critical heating and cooling services.

While initial ideas for integrated planning stay within traditional roles for utility regulators, even broader conceptions of thermal system modernization planning could be enabled by statute as well. Thermal system planning could be akin to the type of geographically oriented planning that occurs in multimodal transportation or for the build-out of sewer systems. Infrastructure planning is something that cities, regions and states know how to do. The challenge is that there is much less experience planning across competing privately owned systems as distinct as electricity, pipeline gas and thermal networks. However, new initiatives for geographic energy planning are beginning globally[67] and could be tested in the United States as well.

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[65] *The Baltimore Sun.* (2017, February 8). Baltimore, BGE mark 200 years of gas light. https://www.newspapers.com/article/the-baltimore-sun-baltimore-bge-mark-20/16787124/

[66] Federal Communications Commission, Order 19-72, WC Docket No. 18-141, 2019. https://docs.fcc.gov/public/attachments/FCC-19-72A1.pdf

[67] See UK's regional energy system planning initiative: National Energy System Operator. (n.d.). *Regional energy strategic planning (RESP).*

This brings us back to an issue briefly raised in section 3. What type of entity is best placed to own and operate thermal energy networks? Should it be first come, first served? Should it be open to individual towns and cities to choose a designated franchisee in their municipality with a right of first refusal to start a municipally owned network? Should there be requirements for incumbent electric or gas utilities to own and operate thermal energy networks? Should there be limitations to *prevent* incumbent electric and gas utility from owning thermal energy networks?

We do not suggest that there will be one-size-fits-all answers to these questions. The pace of rollout for thermal energy networks will likely depend on the economics of the networks and thermal resources themselves and a range of other economic and public policy parameters, notably including electric and gas prices, tax policy and future regulations for GHG emissions and clean heating. But these ownership model questions could feasibly impact the economics of the networks or even the broader evolution of public policy. To illustrate the difficulties of these issues, consider two different possibilities. First, there is a plausible case that gas utilities, with expertise in underground pipe infrastructure, a ready labor force and existing customer relationships, may be best placed to lead on thermal energy networks. However, there is a countervailing case that independent entities, who are not incumbents, may have the clearest interest in spreading new technologies. Those could be municipally owned or independent private entities. For better or worse, this is not a question that can be answered in theory but depends on the intentions and motivation of the leadership of incumbent utilities and potential new entrants. A jurisdiction’s answers to these questions will help shape other regulatory decisions made over time as well, across electric, gas and thermal energy network regulatory spheres.

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https://www.neso.energy/what-we-do/strategic-planning/regional-energy-strategic-planning-resp

7. Conclusion

We are at the beginning of the journey for thermal energy networks as a new shared energy service. In the initial demonstration and development phases, testing and learning is crucial, and there may be setbacks along the way. Supportive regulatory policy can balance the need for risk taking with guardrails to protect customers. Transparency will be crucial to learn quickly and iterate to the best results. If and when thermal energy networks grow in number and size, through development phase to the deployment phase, regulators and other decision-makers will need to provide much more guidance. Clear regulatory road maps are required, not just for thermal energy networks but also for the gas and electric utilities that will be serving customers alongside them and may be competing with them. Through early consideration of the included factors and data from thermal energy networks going in the ground, we will be best able to guide this new energy utility forward in a balanced way.

The energy systems that built our modern world are aging, while we simultaneously grapple with intersecting disruptions and crises. As the globe races to adapt its energy systems to 21st century challenges, the societal choice of energy resources will have far-reaching consequences. During this unique opportunity to reimagine our energy system, local, combustion-free, price-stable, resilient, utility-scale heating and cooling from thermal energy networks can become an important path forward to a safer and more secure energy future. Regulators must weigh this opportunity for a better energy future against the challenges of the present, using careful planning, meaningful community engagement, and clear guardrails to chart a balanced path forward.

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