Summary Report of Information Received in Response to a Request for Information Regarding the Creation of a Thermal Energy Networks Program in Maine

Submitted to the Maine Legislature's Joint Standing Committee on Energy, Utilities and Technology

Pursuant to Resolve 2025, chapter 67

MAINE DEPARTMENT OF ENERGY RESOURCES

Prepared by the Maine Department of Energy Resources in consultation with the Efficiency Maine Trust and the Office of the Public Advocate

January 15, 2026

www.maine.gov/energy

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Acronyms

ASHP	Air Source Heat Pump
DOE	United States Department of Energy
DOER	Maine Department of Energy Resources
EMT	Efficiency Maine Trust
EUT	Joint Standing Committee on Energy, Utilities and Technology
GEO	Governor’s Energy Office (now known as DOER)
GSHP	Ground Source Heat Pump
NLR	National Laboratory of the Rockies
OPA	Office of the Public Advocate
PUC	Maine Public Utilities Commission
RFI	Request for Information
TEN(s)	Thermal Energy Network(s)
UTEN	Utility Thermal Energy Network
WSHP	Water Source Heat Pump

Purpose

Resolve 2025, chapter 67, *Resolve, to Direct the Governor's Energy Office to Solicit Information Regarding the Creation of a Thermal Energy Networks Program in Maine* (L.D. 1619 or the Resolve) was signed into law by Governor Janet Mills on June 11, 2025.[1]

Section 1 of the Resolve directs the Governor's Energy Office (GEO)[2] to solicit information regarding the creation of a thermal energy networks program in Maine, including, but not limited to, relevant frameworks and pilots, information about costs, feasibility and applicability, recommended processes, life-cycle analyses, electric grid impacts, relevance to Maine's statutory emissions reductions goals, labor considerations, and impact on affordability of housing development and energy. For the purposes of the request for information (RFI), "thermal energy network" is defined per the Resolve as 'a system of interconnected piping that circulates thermal transfer water for the purpose of providing low-emissions heating and cooling to 2 or more buildings through the use of water source heat pumps at each building connected to the system.' Per the Resolve, the primary thermal energy source for such a network may include, but is not limited to, geothermal resources or recovered thermal energy, such as waste heat captured from buildings or wastewater systems.[3]

Section 2 of this Resolve directs the GEO to prepare, in consultation with the Efficiency Maine Trust (EMT) and the Office of the Public Advocate (OPA), a summary report regarding the information received in response to the RFI and, by January 15, 2026, to submit the report to the Joint Standing Committee on Energy, Utilities and Technology. The Resolve specifies that GEO may develop and include in the report recommendations regarding the development of a thermal energy networks program in the State.

On September 18, 2025, an RFI was issued by the Maine Department of Energy Resources (DOER) which invited all interested parties to respond by October 17, 2025. This report summarizes all comments received through the RFI to meet the requirements of the Resolve. Existing staff resources were used to complete this report as additional funding was not provided by the Resolve.

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[1] Resolve 2025, chapter 67 (June 11, 2025)
[2] Now known as the Maine Department of Energy Resources since, P.L. 2025 ch. 476 *An Act to Establish the Department of Energy Resources* (L.D. 1270) became effective law September 24, 2025.
[3] Resolve 2025, chapter 67 (June 11, 2025)

Overview of Report

This report addresses the topics as laid out by the Resolve and includes information collected through the RFI. It is organized into four main sections.

- **Summary of Recommendations** provides a concise overview of recommendations developed through the RFI process and review of responses.
- **Thermal Energy Networks** discusses background information on energy networks and their application through geothermal energy.
- **Summary of Responses to Request for Information** discusses the received responses via the RFI issued by DOER.
- **Recommendations** concludes the report with policy recommendations and considerations.

An appendix is also included, which provides the Resolve text, a copy of the RFI, and responses to the RFI in full.

Summary of Recommendations

The recommendations in this report reflect the information received through the RFI and emphasize the importance of continued learning as the next steps related to thermal energy networks (TENs) are considered in Maine. The next steps should be informed by ongoing and forthcoming state studies, including the Geothermal Power Plant Opportunities Study (L.D. 300), and should prioritize structured scoping work to clarify the role these systems could play within particular sectors in Maine as well as Maine's broader energy strategies. Key themes include:

- **Continue Building the Information Base:** TENs represent a potential option for reducing building emissions and system impacts of heating; however, available information regarding specific costs, best practices, and site feasibility is limited. Additional data and analysis are needed to better understand the most beneficial types of applications in Maine. The RFI did not receive direct participation from electric or gas utilities and no responses from entities that have themselves implemented TEN pilots in comparable cold-climate regions. Robust operational and cost-benefit data from these entities will be critical. Additional engagement with trusted organizations producing emerging guidance and best practices, such as the National Association of State Energy Officials (NASEO) and the National Laboratory of the Rockies (NLR), could also help address current information gaps.
- **Engage with Experienced Implementers:** Further outreach to developers, utilities, campus operators, and public entities that have implemented TEN projects and pilots – particularly in cold-climate regions – would provide valuable insight into system performance, costs, and operational considerations. Consider working with project implementers to gain access to operational data and cost information where it isn't publicly available and identifying a framework for evaluating pilot data in a consistent and comprehensive manner.
- **Differentiate Applications by Project Type:** Application of TENs in new construction developments may offer different opportunities and challenges compared with retrofit applications. More information is needed to understand how the different cost and technical considerations of these approaches compare. While new construction (e.g., campuses or coordinated multi-building developments) may allow for more efficient, integrated system design, retrofit applications may involve higher and more variable costs and could require phased development approaches, making careful site screen and cost analysis particularly important. Working to develop a site screening tool could prove useful in identifying the most promising locations for potential pilots.

- **Clarify Regulatory and Coordination Considerations:** Early attention should focus on understanding coordination needs, permitting considerations, available cost-sharing methodologies, and stakeholder roles, rather than on developing new regulatory frameworks. A review focused on identifying major uncertainties – such as cost allocation and roles among participants – could help reduce friction for early demonstration or pilot projects.
- **Leverage External Resources and Ongoing Research:** Monitor emerging guidance, best practices, and federal assistance opportunities and resources including low-cost technical assistance from trusted organizations such as the United States Department of Energy's (DOE's) national laboratories to help inform future decision-making regarding policy interventions while limiting near-term risk. This may include federal planning support, technical assistance, and financial or tax incentives, as well as public-private partnerships or collaboration with utilities that could help reduce upfront costs and risks for initial pilots.
- **Account for Workforce Considerations:** Workforce and training considerations should remain part of early planning to ensure training and credentialling requirements are aligned and ensure that Maine's workforce is prepared if a market for thermal network deployment emerges in Maine. Early alignment of training programs, credential pathways, and labor standards could help position skilled trades and technical professionals to participate in future TEN development.

Overall, these recommendations emphasize continued evaluation of existing public and privately developed projects and pilots to identify the most promising applications for TEN development in the Maine context. This approach is intended to support practical, informed, and cost-effective next steps that are aligned with the state's long-term energy goals.

Thermal Energy Networks

Energy Networks

There are a variety of terms used, sometimes interchangeably, to refer to systems that utilize shared infrastructure to provide heating and/or cooling to multiple buildings.

A common term used is a district energy system, where "thermal energy is provided to multiple buildings from a central energy plant or plants."[4] District energy systems, as a technology, have existed since the 19th century—these early systems distributed steam from large coal boilers to serve the heating needs of multiple adjacent buildings. District energy systems are often referred to based on their "generation," as defined by the International Energy Agency Technology Collaboration Program on District Heating and Cooling (IEA DHC) as summarized in Table 1.[5]

Table 1: Summary of Generations of District Energy Systems

Generation	Notable features
1st	Use steam instead of liquid water for its heat supply.
2nd and 3rd	Use heated (i.e., greater than 70 degrees Celsius) water as the heat supply, requiring additional energy use to maintain these temperatures.
4th	Use lower temperature, often ambient water, as the heat supply.
5th	In addition to using lower temperature water, use decentralized technology (i.e., heat pumps) at the building level, rather than a large central plant.

Thermal energy networks (TENs) are a subset of district energy systems which specifically use a shared network of water-filled pipes and building-level heat pumps to transfer heat in and out of buildings in an efficient, low-carbon manner that does not require on-site combustion.[6] 5th generation district energy systems and TENs are often referenced interchangeably.[7]

Specifically, as defined by the Resolve for the purposes of this report, a TEN is:

> *"…a system of interconnected piping that circulates thermal transfer water for the purpose of providing low-emissions heating and cooling to 2 or more buildings*

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[4] "District Energy Systems Overview" U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

[5] "District heating network generation definitions" IEA DHC. February 2024. https://www.iea-dhc.org/fileadmin/public_documents/2402_IEA_DHC_DH_generations_definitions.pdf

[6] "Thermal Energy Networks." Building Decarbonization Coalition, https://buildingdecarb.org/initiatives/tens

[7] Ibid.

through the use of water source heat pumps at each building connected to the system."

The Resolve further specifies that the primary thermal energy source for such a network may include, but is not limited to, geothermal resources or recovered thermal energy, such as waste heat captured from buildings or wastewater systems.

TENs rely on a variety of diverse heat sources to provide thermal energy for the system. A few feet below the surface, the earth maintains a stable temperature of roughly 55° F year-round, which can be harnessed by borehole fields that store or recover this heat seasonally.[8] Additionally, thermal energy for TENs can include recoverable waste heat from buildings, industry, or infrastructure, all of which can be captured and redistributed instead of being vented to the air.[9] The majority of TENs are comprised of multiple heat sources to "opportunistically use the resources of the location."[10]

TENs are able to provide both heating and cooling due to the stable temperature of the water circulating throughout the system: it's more efficient to heat or cool to 65° F when utilizing a more constant (i.e., ~55° F) starting point. Unlike air-source heat pumps (ASHPs) which draw energy from the ambient air, the majority of modern TENs use water- or ground-source heat pumps (WSHPs or GSHPs) in each building to exchange heat with ambient sources. This is illustrated in Figure 1.[11]

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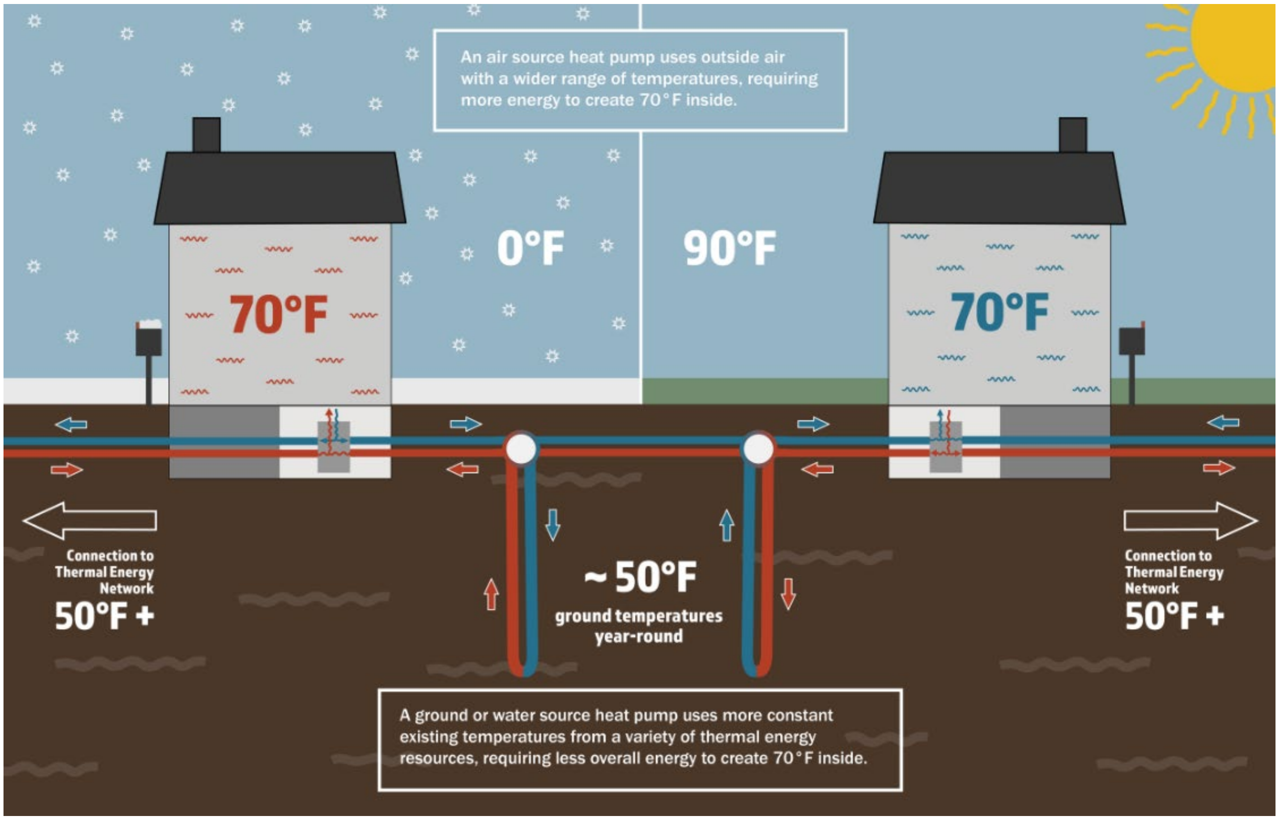
[8] "Heating, Cooling, and Storage Technologies." NLR, December 3, 2025, https://www.nrel.gov/geothermal/heating-cooling-and-storage-technologies

[9] "NREL-Led Team Explores Potential of Underground Geothermal Energy Storage for All Seasons." NLR, March 9, 2023, https://www.nrel.gov/news/detail/program/2023/nrel-led-team-explores-potential-of-underground-geothermal-energy-storage-for-all-seasons

[10] "Thermal Energy Networks." Building Decarbonization Coalition.

[11] "Geothermal Heating & Cooling." U.S. Department of Energy. https://www.energy.gov/eere/geothermal/geothermal-heating-cooling

Figure 1: Efficiencies of TENs and GSHPs[12]

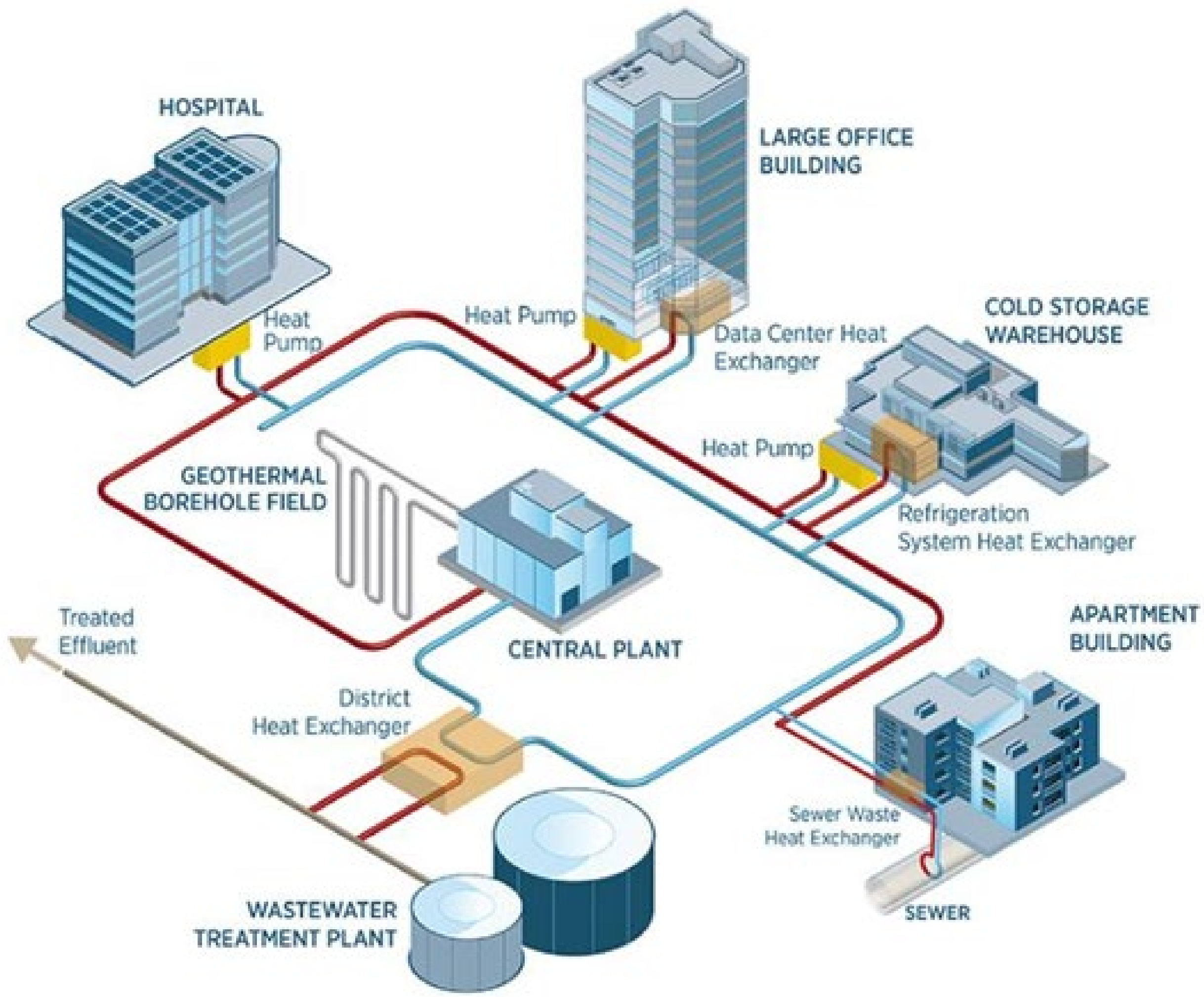


TENs are comprised of a system of buildings, enhancing their ability to benefit from and utilize diverse heat sources to improve overall system efficiency. Waste heat from one building (or heat from other connected sources; i.e., a sewer system or a surface water source) can be used to more efficiently heat the system in the winter; in the summer, since the piped water is at a lower temperature than the air, it can more effectively absorb heat from the system and provide cooling.

Even within modern TENs, there are several design approaches used (i.e., the number of pipes, the types of thermal sources, open vs. closed loop). A TEN is a broad term that can encompass a variety of design choices to best meet the needs and opportunities of the community in which it is placed. One example of a thermal energy network can be found in Figure 2.[13] This visual illustrates multiple sources of obtaining energy from ambient sources (e.g., borehole field, sewer heat recovery, wastewater). Building types within a TEN vary and can include both residential and non-residential building types.

[12] “The Basics.” Vermont Community Thermal Networks. https://www.vctn.org/the-basics
[13] “Full Steam Ahead: Unearthing the Power of Geothermal.” NLR, March 7, 2023, https://www.nrel.gov/news/detail/features/2023/full-steam-ahead-unearthing-the-power-of-geothermal

Figure 2: Thermal energy network example



Geothermal energy

Thermal energy networks are just one application of harnessing geothermal energy. The earth's underground temperature can be used in several ways: shallow geothermal or "ground-source" heat pump systems for building heating and cooling, borehole fields that store or recover heat seasonally (i.e., for TENs), and in deep geothermal systems capable of generating electricity in areas with higher-temperature resources, and more.[14] Geothermal electricity generation requires specific geologic conditions, namely sufficient heat found in

[14] "Resource Exploration and Characterization." NLR, December 7, 2025, https://www.nrel.gov/research/re-geothermal

rocks deep underground; fluid to carry the heat from the rocks to the surface (although technological advances are reducing the need for this variable); and permeable pathways to facilitate fluid movement through the hot rocks.[15] Geothermal electricity production typically occurs thousands of feet below the surface. Conversely, GSHP and borehole TEN systems harness geothermal heat that is present at much shallower depths and do not require specific geologic variables though other variables such as bedrock conditions and soil saturation can have cost implications.

While TENs are a relatively novel concept in Maine, individual GSHP systems are already a component of the state's heating mix. The primary distinction is that GSHPs serve one building and are not connected to a larger system, as discussed above, a TEN includes GSHPs. Further, TENs can be applied to a single-customer campus (e.g., university, etc.) or a variety of multi-customer buildings.

Ground Source Heat Pump Programs in Maine

The Efficiency Maine Trust (EMT) is a quasi-state agency established to plan and implement energy efficiency programs in Maine. EMT administers a geothermal system (defined as ground source, or geothermal, heat pump) rebate program in the state, offering a rebate for 1/3 of the project cost up to $3,000 with a lifetime limit of one geothermal rebate per housing unit.[16] Homeowners of any income can claim a rebate given the project meets the following eligibility criteria:

- An *Energy Star* geothermal heat pump is installed;
- The installation occurs in the primary living area of a principal year-round residence that is a single-family house, two-unit duplex, condominium, or mixed-use building with one or two housing units and no commercial electrical meter(s);
- A residential registered vendor for geothermal systems completes the installation; and
- The rebate is claimed within six months of project completion.

Based on EMTs Residential Registered Vendor list, there are 15 registered geothermal system installers with 10 based in Maine. Table 2 summarizes the number of residential geothermal system rebates claimed through EMT between FY2023-2025.

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[15] "Electricity Generation." U.S. Department of Energy Geothermal Technologies Office. https://www.energy.gov/eere/geothermal/electricity-generation

[16] "Geothermal Heat Pump Rebates." Efficiency Maine Trust. https://www.efficiencymaine.com/at-home/geothermal/

Table 2: EMT Rebates for Geothermal Heat Pump Systems (FY 2023-2025)

Fiscal Year	Number of Ground Source Heat Pump Rebates
2023	29
2024	28
2025	27

EMT's Commercial and Industrial Custom Program (C&I Custom) provides incentives for tailored energy efficiency and distributed generation projects. Funding provided by the program can range from a minimum of $10,000 to a maximum of $1 million per customer per fiscal year. C&I Custom funding is available for "efficiency projects that reduce the use of natural gas, oil, biomass, and other fuels," including TENs.[17] Projects implemented through EMT's C&I Custom program tend to include upgrades to components of an existing distributed energy network. Data on the number of TENs installed utilizing the C&I Custom program was not available at the time of this report.

Summary of Responses to Request for Information

Methodology

In consultation with EMT and OPA, DOER developed an RFI consistent with the Resolve. The RFI was published on September 18, 2025, and remained open until October 17, 2025. It was advertised through multiple channels, including the DOER website and newsletter, as well as to those who testified on L.D. 1619. A copy of the RFI can be found in the Appendix.

DOER received a total of 10 responses from a range of stakeholders. A list of respondents and their organizations are provided in Table 3. DOER received no submitted information or comments from regulated utilities serving electric and natural gas customers.

Following the closure of the RFI, DOER staff reviewed all submitted responses. Respondents were not required to answer every question; therefore, individual organization names are referenced where relevant. The sections that follow are organized according to the question structure of the RFI. In instances where the respondent did not specify which question they were responding to, responses were included in the section deemed most relevant.

[17] "Commercial and Industrial (C&I) Custom Program." Efficiency Maine Trust. https://www.efficiencymaine.com/at-work/commercial-industrial-custom-program/

Table 3: RFI respondents and organization descriptions

Respondent	Description of Respondent
GeoExchange	GeoExchange is "a nonprofit trade association promoting the manufacture, design, and installation of geothermal heat pump heating and cooling technologies. Their members include manufacturers, installers, technology providers, utilities, and others in Maine and across the country,"
Buro Happold (BH)	Buro Happold is "a professional services firm that provides engineering, design, planning, and project management consulting. Buro Happold's Energy team specializes in decarbonization strategy, distributed energy resources, and utility-scale planning and has experience in the design of district energy systems" (including TENs).
International District Energy Association (IDEA)	IDEA is "a nonprofit industry association that represents 3,000 members from more than 25 countries. IDEA's member organizations own, operate, or provide technology and services to district energy systems."
CLEAResult Energetics (CLEAResult)	CLEAResult's Energy Sustainability Consulting division, Energetics, is "a 120-person clean energy consultancy based in Columbia, MD."
International Brotherhood of Electrical Workers Local Union 1253 (IBEW 1253)	IBEW 1253 is "a union of more than 300 construction electricians with a jurisdiction that spans from Eastport to Rockland along the coast and inland from Lincoln to Jay."
WaterFurnace International (WFI)	WFI "manufactures and distributes geothermal and water source heating and cooling systems for residential, commercial, and institutional buildings internationally."
Solen Works	Solen Works is "a sustainability consulting firm and innovation lab dedicated to accelerating climate-positive solutions in the built environment."
Maine Labor Climate Council (MLCC)	MLCC is "a coalition of labor organizations advocating for a pro-worker, pro-climate agenda in Maine."
Sierra Club Maine and the Portland Climate Action Team (PCAT)	Sierra Club Maine has over 20,000 supporters and members in Maine. Sierra Club is one of the nation's oldest and largest environmental organizations and the PCAT is "composed of Portland and surrounding towns' residents who want to take meaningful action to promote clean energy."
Efficiency Maine Trust (EMT)	EMT is "the independent, quasi-state agency established to plan and implement energy efficiency programs in Maine. Through its suite of nationally recognized programs, Efficiency Maine provides consumer information, marketing support, demonstration pilots, discounts, rebates, loans, and other initiatives to promote high-efficiency equipment and

Respondent	Description of Respondent
	operations that help Maine's homes, businesses, and institutions reduce their energy costs and lower their greenhouse gas emissions."

The following sections provide an overview of RFI responses by question. The RFI is available in full in the Appendix.

Relevant Research, Framework, Pilot Projects, System Configurations

Respondents were asked to provide information on any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country.

Solen Works included information summarizing the differences between different "generations" of TEN technologies, noting that most modern district energy systems are now fourth (4^{th}) generation.[18] Fourth generation systems, as characterized by Solen Works, distribute water at ambient temperature to building-level heat pumps that provide the final temperature lift. The benefits of this decentralized model are (1) the low distribution temperatures which allow for very little thermal losses (less than 5% over extended distances), (2) bidirectional energy sharing (i.e., waste heat from buildings requiring cooling can warm the network for buildings requiring heating), (3) integration with diverse thermal sources including shallow geothermal, wastewater heat recovery, surface water exchange, and industrial process waste heat, and (4) the distributed heat pump architecture provides resilience through redundancies built into the system.[19] Solen Works notes that ground-source heat pumps in TENs often operate at coefficients of performance (COPs) between 3.5 to 5.0 (i.e., for every kilowatt-hour of electricity consumed, 3.5-5.0 kilowatt-hours of heating are delivered to the building), compared to 0.7-0.85 for traditional combustion heating systems and 1.8-2.5 for air-source heat pumps). BH noted that modern TENs rely on fifth (5^{th}) generation technology and that these systems can utilize various pipe configurations (i.e., 1, 2, or 4 pipes). BH mentions similar benefits realized by single-pipe fifth generation systems, including that single-pipe systems are currently the most popular and enable diverse heating and cooling loads to share thermal energy across buildings, with water serving as the primary circulating heat transfer fluid. Anti-freeze can be added for protection depending on the climate.

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[18] For an overview on the evolution of TENs and their respective generations, please see: https://buildingdecarb.org/resource-library/ten-definitions

[19] Lund, H. et al. "4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems" 2014, Energy, 68, 1-11.

A number of respondents introduced pilot projects that have been undertaken or completed across the U.S., Europe, and Canada. The Sierra Club noted that TENs have been applied in climates ranging from Texas to Minnesota and projects have been initiated in at least 20 U.S. states. The IBEW 1253 included that at least 12 states have passed significant legislation with eight of these states authorizing or requiring IOUs to develop utility TEN (UTEN) pilots.[20] Of these projects, the IBEW 1253 specifically highlights that New York State directed the New York Power Authority (NYPA) to develop decarbonization action plans for the 15 highest emitting state-owned facilities, and this planning process resulted in $200 million being budgeted for the most shovel-ready TENs at these sites.

The Sierra Club and Solen Works further highlighted that TENs also have been established outside the U.S., with India, Germany, France, and the UK predicted to exceed the U.S. in rate of investment in TEN facilities.[21] Canada already heats 3% of its building stock with TENs.[22]

Pilot and full-scale projects included in responses are summarized in Table 4.

Table 4: Pilot and full-scale projects included in RFI responses

Project Location (RFI Respondent)	**Project Description**
Framingham, Massachusetts (EMT)[23]	125 customer accounts (i.e., 36 buildings – 24 residential and 5 commercial) installed in a single-loop system with two borehole fields. Initial estimates in 2020 for the pilot cost was $14,061,769 (i.e., drilling wells, installation of heat pumps, internal labor, heat pump units, distribution piping, ductwork). In 2024, new estimates were $27,075,958. A brief in the regulatory proceeding noted that construction costs were the primary cause of the overrun. Total project costs (before tax credits) are ~$200,000 per household or $77,500 per ton of thermal capacity.
Malmo Bo01, Sweden (Solen Works)[24]	1,300 residential units and 12,000 square meters of commercial space. Completed in 2001 and combines aquifer thermal energy storage and solar thermal collectors covering 3,000 square meters of roof area. The project purchases wind renewable energy

[20] These pilots in development serve a wide range of building types with various system configurations including systems serving mixed-used neighborhoods, public housing complexes, and projects that integrate data centers to beneficially utilize waste heat.

[21] "District Heating and Cooling Market." Future Market Insights, October 6, 2025, https://www.futuremarketinsights.com/reports/district-heating-and-cooling-market

[22] "Thermal Energy Networks in Canada: Unlocking Impact Potential and Advancing Enabling Policy." Building Decarbonization Alliance, September 25, 2025, https://buildingdecarbonization.ca/report/thermal-energy-networks-in-canada/

[23] NSTAR Gas Company d/b/a Eversource Energy, GEP Annual Filing, D.P.U 24-114, August 1, 2024, pg. 13

[24] City of Malmö Energy Department, "Bo01 District Energy Performance Report" (2018)

Project Location (RFI Respondent)	Project Description
	certificates (RECs) to provide 100% renewable energy for the project. The district energy system operates as a low-temperature network with supply temperatures of 85 to 120° F, substantially lower than traditional Swedish district heating systems with a coefficient of performance (COP) of 3.5-4.5 across the heating season. Municipal co-op owns and operates the distribution infrastructure with building-level systems owned and maintained by building associations.
Princeton University, New Jersey (Solen Works)[25]	According to commenters, this is the largest institutional retrofit in North America of an existing natural gas fired steam plant serving 180 buildings and 15 million square feet. In 2012, the existing natural gas system required significant renovations due to the infrastructure reaching the end of its useful life. The technical TEN replacement solution involved installing more than 2,000 geothermal boreholes across campus at depths of 600-800 feet. These closed-loop wells circulate water through a new district system selected to interface with existing building heating systems designed for higher temperature water, reducing building-side retrofits. Phased implementation over ten years; as buildings undergo major renovations, they transition to lower temperature hydronic systems or direct expansion heat pump systems.
Private School Campus, New Hampshire (Solen Works)	2,000-acre campus with 90 buildings. Multi-phase decarbonization approach: 1) envelope improvements, 2) ground-source heat pump systems serving clusters of buildings (300 geothermal bores at 500-foot depth for distributed water-water heat pumps) designed using existing hydronic distribution within buildings while replacing boilers with heat pumps. Backup propane boilers retained for emergencies and thermal storage tanks installed for load shifting capabilities.
Alfond Center, Roux Institute, Maine (Solen Works)	245,000 square feet of new construction which plans to incorporate 82 geothermal wells at 500-foot depth. During the study phase, a campus approach was considered with a seawater heat exchanger with Caso Bay and an ambient temperature loop at 50-70 degrees; seawater system was deemed not economically feasible due to quantity of piping and materials required.
Whistler Athletes' Village, British	250 residential units served by wastewater-source district energy system. The technical approach extracts thermal energy from treated wastewater effluent after final treatment but before it is discharged to the river. Due to a requirement which limits the

[25] Princeton University Facilities, "Geothermal Energy System Overview" (2023)

<table>
<tr><th>Project Location (RFI Respondent)</th><th>Project Description</th></tr>
<tr><td>Columbia (Solen Works)[26]</td><td>temperature drop in the wastewater to four degrees to protect downstream habitats, the wastewater system provides approximately 95 percent of the neighborhood's annual heating needs. Municipal ownership of system with thermal service provided to building owners as a regulated utility service. System was expanded to 750 units in 2023 through extension of distribution piping. The key requirement was proximity of the wastewater facility to dense heat demand.</td></tr>
<tr><td>Multiple New York TEN pilot projects (IDEA)</td><td>IDEA included a table that shows construction costs, square feet, and cost per square foot for six projects that have advanced in the New York TEN pilot project design and evaluation process. Construction costs range from $52.4-191.7 million, with building area served ranging from 316,384-6,690,500 square feet. Costs per square foot of TEN system exceeded the average cost per square foot of a new construction for two of six projects.
<table>
<tr><th></th><th>System Type and Thermal Source</th><th>Construction costs ($M)</th><th>Square feet of building space served</th><th>TEN construction cost ($/SF building space served)</th></tr>
<tr><td>A</td><td>2-pipe Ambient Loop, Treated Sewage Effluent</td><td>$ 126.4</td><td>1,695,136</td><td>$ 75</td></tr>
<tr><td>B</td><td>2-pipe Ambient loop with geoexchange, refrigeration waste heat, sewer heat recovery and cooling tower.</td><td>$ 112.6</td><td>316,384</td><td>$ 356</td></tr>
<tr><td>C</td><td>2-pipe Ambient Loop fed from chiller waste heat, for heat only</td><td>$ 83.8</td><td>6,690,500</td><td>$ 13</td></tr>
<tr><td>D</td><td>2-pipe Ambient Loop fed from chiller waste heat</td><td>$ 52.4</td><td>815,000</td><td>$ 64</td></tr>
<tr><td>E</td><td>2-pipe Ambient Loop with geoexchange</td><td>$ 191.7</td><td>432,170</td><td>$ 444</td></tr>
<tr><td>F</td><td>Two single pipe ambient loops using sewage thermal recovery</td><td>$ 118.1</td><td>N/A</td><td>N/A</td></tr>
</table></td></tr>
<tr><td>Sewell's Landing, Vancouver (BH)[27]</td><td>12-story, 158 residential units split between six buildings served by centralized ocean source heat pump-based mechanical system. Closed-loop configuration with stainless-steel heat exchanger in Horseshoe Bay providing a low-grade heat source and sink. 90% of thermal energy is provided via this system. Noted challenges navigating sensitive marine habitats and permitting/regulatory requirements. No cost estimates were provided.</td></tr>
<tr><td>Enwave, Toronto (BH)[28]</td><td>200 buildings and more than 40 million square feet of downtown real estate are served. Buildings connect in a phased approach to</td></tr>
</table>

[26] Whistler Village District Energy Award Summary, 2013

[27] "Projects: Sewell's Landing." Introba, https://www.introba.com/work/projects/sewells-landing

[28] "Toronto: Empowering one of North America's fastest-growing city." Enwave, https://www.enwave.com/locations/toronto

Project Location (RFI Respondent)	Project Description
	existing district energy system of 4 interconnected downtown plants and 25 miles of underground pipes. District energy network is anchored by Deep Lake Water Cooling system; combined heat and power system is grid connected with a total capacity of 4 MW. System launched in 2004 and now saves roughly 90,000 MWh of electricity annually. The cost of the system was approximately $120 million USD.
Epic Corporation, Wisconsin (BH)[29]	40 connected buildings and 9 million square feet of building space including cooling support for a 3.5 MW data center and spare capacity to accommodate growth. 6,100 boreholes across 4 borehole fields and 2 lake exchange systems. Epic consumes about 25% less energy than comparable buildings in the same climate.
Smith College, Massachusetts (BH)[30]	Three-phase (1st-phase = 80 boreholes) geo-exchange network scheduled for completion by 2028 at an estimated 30-year discounted lifecycle cost of $279 million, about $60 million less than BAU estimates. Each phase will construct a geothermal district, each of which will have an exchanger. Sourcing renewable electricity to offset additional usage.
Saint Paul, Minnesota (BH)[31]	$4.7 million loan (estimate $12 million total project costs) to establish the Heights Community Energy which plans to construct and operate a district geothermal energy system (aquifer thermal energy storage) at The Heights development, a 1,000-unit community under construction on the East Side of Saint Paul.

In addition to the above pilot projects, the Sierra Club included an Applied Economics Clinic of Massachusetts study[32] which concluded that TENs heating is the most economical way to heat the average-sized home in Massachusetts, with life-time costs already less than ASHP and natural gas as of 2020 and projected continued cost declines.

[29] "Geothermal Heat Pump Case Study: Epic Systems Corporation." U. S. Department of Energy, https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-study-epic-systems-corporation

[30] "Neighborhood-Scale Building Decarbonization Map." Building Decarbonization Coalition, https://buildingdecarb.org/neighborhood-scale-projects-map; "Geothermal heating and cooling: Renewable energy's hidden gem." Yale Climate Connection, August 4, 2022, https://yaleclimateconnections.org/2022/08/geothermal-heating-and-cooling-renewable-energys-hidden-gem/

[31] "The Heights Awarded $4.7 Million for Geothermal Energy System." Saint Paul Minnesota, March 27, 2024, https://www.stpaul.gov/news/heights-awarded-47-million-geothermal-energy-system

[32] "Inflection Point: When Heating with Gas Costs More." Applied Economics Clinic, March 2021, https://static1.squarespace.com/static/5936d98f6a4963bcd1ed94d3/t/6054bb9ff7a55b4c78010d53/1616165792748/Inflection+Point_White+Paper_AEC_Revised_19Mar2021.pdf

An EnergySage report[33], also referenced by the Sierra Club, stated that GSHPs can achieve 600% efficiency while ASHPs can achieve only up to 400%. IBEW 1253 also put forward their view that TENs are one of the lowest-emission and most efficient technologies to heat and cool buildings.

EMT and IDEA included suggested frameworks to evaluate the feasibility of TENs projects. EMT introduced a framework to specifically evaluate existing pilot projects, and recommends determining (1) if project costs remained consistent with initial cost estimates, (2) if pilots encounter any unexpected challenges, and (3) how pilot costs were recovered. EMT noted that existing pilots, particularly Framingham, MA, have seen significant cost overruns and that these lessons learned can be especially important for Maine. IDEA referenced seven keys to cost-effective TENs, including (1) high thermal load density, (2) high load diversity, which reduces system peak demand, (3) good site access to low or no carbon energy sources, (4) right-sized high-capex capacity, (5) service to new construction, which is significantly more cost-effective than retrofitting, (6) rapid growth of the system, which allows growth of revenue to better keep pace with cap investment, and (7) incorporation of Thermal Energy Storage (TES) to reduce peak electricity demand and optimize heat pump output.

Feasibility and Applicability in Maine

Respondents were asked to provide information on feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in Maine, which may include information related to (1) geophysical considerations, (2) compatibility with incumbent air source heat pumps and other heating, ventilating and air-conditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network, (3) permitting and right-of-way considerations, (4) constraints around geographic density, and (5) other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks.

Geophysical Considerations

BH noted that successful projects will have high technical (i.e., availability of thermal resources, building thermal demand, building typology and occupancy patterns, integration with existing thermal and energy systems), economic (i.e., funding mechanisms, payback period, and macro-economic factors), and social (i.e., participation rates and environmental justice (EJ)) feasibility. BH concluded that Maine has sufficient technical feasibility to install shallow wells (up to 800 feet) and references a Martzolf

[33] "Air source heat pumps vs. Geothermal heat pumps." EnergySage, April 17, 2025, https://www.energysage.com/heat-pumps/compare-air-source-geothermal-heat-pumps/

study[34] that noted that the thermal flux at wells around the state is consistent with other regional thermal conductivities where successful TENs have been constructed. Multiple respondents noted that newer (i.e., fourth generation) hybrid closed loop systems, where a water well is constructed and either a U-loop assembly or direct heat exchanger is installed within the water well to take advantage of groundwater flow across the screened interval, are likely most relevant technically and economically to Maine.

To reduce overall system costs, BH, WFI, Solen Works, Sierra Club and others noted that TENs can utilize low-grade thermal fluxes (i.e., large water bodies like lakes, oceans, rivers, retention ponds, etc.) in open or closed loop systems. WFI specifically noted that vertical boreholes adjacent to storm retention ponds are not uncommon, providing consistent or better heating and cooling for a fraction of the cost.

TENs can also integrate other thermal sources, particularly resources that produce energy waste by-product, to serve as heating, rejection, or storage centers. Common examples, as referenced by BH and Solen Works, can include data centers, cold storage or food processing facilities, plastics manufacturing, paper mills, waste-to-energy facilities, biomass facilities, ice rinks, wastewater treatment plants, or above ground storage tanks. WFI referenced a project in Kansas City, Missouri which reduced the size and cost of the loop field by 30% simply by adding domestic water heating to the design and stated that many TEN projects are deemed impractical due to lack of understanding or awareness or due to anticipated cost of underground infrastructure or ground heat exchanger, costs which can be mitigated by effective designs. Solen Works believes that Maine's four largest cities (i.e., Portland, Augusta, Lewiston, Bangor) could utilize similar designs to the system developed for the Whistlers' Athletes Center (Table 2) which leverages a wastewater treatment center.

BH included that the National Renewable Energy Laboratory (now the National Laboratory of the Rockies[35]), through its ComStock and ResStock modeling databases, maintains data that generalizes thermal loads across building typologies; diverse load profiles with different heating and cooling demands will result in a more successful TEN.

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[34] Martzolf, D. 2016. Atalas of Maine: Geothermal Heat Conductivity of the Bedrock of Maine, Atlas of Maine. Vol. 2016: No. 1, Article 7. https://digitalcommons.colby.edu/atlas_docs/vol2016/iss1/7/#:~: text=Article%20Title,science%20minor%20at%20Colby%20College.

[35] "News Release: Energy Department Renames NREL 'National Laboratory of the Rockies'." NLR, December 1, 2025, https://www.nrel.gov/news/detail/press/2025/news-release-energy-department-renames-nrel-'national-lab-of-the-rockies'

Compatibility with Incumbent Systems and Retrofitting

EMT noted the significant challenges faced during its initial pilot to demonstrate the performance of air-to-water heat pump technology configured with hydronic distribution systems. Based on these challenges, EMT recommends investigating how TENs can produce hot enough temperatures to be compatible with the heating distribution systems (i.e., forced hot water radiators or forced hot air ducts) that are prevalent in Maine. If TENS are not compatible, EMT suggests investigating whether there are low-cost ways of retrofitting existing systems.

BH noted that due to the nature of installing a TEN, it is likely and sometimes optimal, for backup heating systems to remain. Electric based systems are preferable though natural gas or delivered fuel-based systems can be sufficient if the useful life has not expired. The key consideration for leveraging these legacy systems is to use hydronic based distribution to allow integration with the TEN, thereby increasing efficiency and decreasing costs. WFI recommends consulting a neutral "owner's representative" prior to site selection, as the right type of equipment will significantly lower costs. Considerations of how to merge a ground source heat pump with an existing system(s) should begin during site selection.

Permitting and Right-of-Way Considerations

The Sierra Club put forward that permitting and right-of-way issues and procedures may be very similar to those managed by electric, natural-gas, and water utilities. Procedures at the local level already exist for this type of permitting. CLEAResult emphasized that due to the relative novelty of TENs, maintenance and system upgrades can be complex. CLEAResult recommends expedited and/or prescriptive permitting for select portions of the system to offer upfront clarity.

Geographic Density Constraints

The majority of respondents noted that TENs are most effective in areas with sufficient geographic density (i.e., multifamily residential buildings, corporate campuses, commercial districts, particularly those with mixed uses and shared amenities in urban cores). BH noted that population density, heat density, new construction opportunities, and local availability of thermal energy tend to be key screening criteria for TENs. BH further noted that the requirement of population density does not necessitate TEN development in strictly urban areas. While less than 40% of Maine's population lives in urban areas, small communities, town centers, and areas currently served by natural gas utilities could have sufficient density and an economic case to be settings for TENs. BH suggested that: "When considering the feasibility of TENs, one rule of thumb would be to use the existing natural gas service territories. If natural gas lines were installed within a given area, there is likely an economic case for the installation of a TEN."

CLEAResult noted the benefit of shared infrastructure and walls within buildings, which results in lower per-occupant heating loads and costs. However, while multifamily residential buildings enhance viability due to proximity, they often offer little load diversity. Multiple respondents similarly noted that load diversity can achieve beneficial synergies, as TENs are designed to share thermal energy. CLEAResult also noted that TENs are highly applicable and beneficial to industrial uses (e.g., food and beverage manufacturing) that require substantial volumes of steam, hot water, hot air, and other thermal uses. The limiting factor to installing TENs for these industrial applications is generally pipeline infrastructure in rural areas, which is typically where these industrial uses are sited. CLEAResult and WFI both noted that rural areas may still be viable due to land availability and community-scale systems that offer cost advantages.

WFI offered an example of the tradeoffs due to siting in dense urban areas, using Portland as an example. WFI believes the advantages include numerous customers that can be linked together in a small network, facilities adjacent to the harbor which is an ideal heat source and sink, substantial load diversity, and existing electrical infrastructure. WFI believes the disadvantages include minimal "open space" for vertical drilling, if necessary, hundreds of years of uncharted below ground infrastructure, and foot or vehicle traffic in relation to construction. This example also highlights the critical need to identify intersections with existing infrastructure during site selection. These challenges can be mitigated in less urban areas and with new construction opportunities.

Other Considerations

CLEAResult and WFI both included references to the benefits of diurnal switching during Maine's shoulder seasons to improve the efficiency of a TEN. For example, during a cold October night, a system could draw heat from a TEN and later the same day, when the sun heats up the building and the air, the volume of water in the TEN would reabsorb that heat without significantly tapping the ground source. WFI also noted that due to Maine's low ground water temperatures, there is a high potential for low-cost heat pump operation.

Considerations for Facilitating Potential Pilot Projects

Respondents were asked to provide information on considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms.

CLEAResult introduced the benefit of pilot projects due to the high barrier to entry of permitting, construction, environmental assessment, geotechnical surveys, etc. that make TENs less desirable for market-rate construction. Oftentimes such investments require financial assistance and demonstration projects. CLEAResult has seen success in Colorado, where it supports two geothermal programs. Colorado offers grant funding for technical assistance to evaluate TEN pilot feasibility which reduces preconstruction barriers and uncertainty. BH similarly notes that due to risk and availability of funding, the majority of full-scale projects have occurred at public and private universities and private companies.

BH outlined three primary ownership models – private, public-private partnership (P3), and third party. Private ownership allows for the most flexibility and are the most common to date, including institution and utility TENs (UTEN). P3s are typically used for municipalities or towns and offer a hybrid option that allows for some local involvement in decision making. Third party allows for private investment and long buy-back, making it an attractive option when capital is not readily available. BH cited a variety of UTEN, private, and P3 projects (see Table 2).

The MLCC mentioned the difficulty in scaling TENs, specifically UTENs, without placing undue burden on the broader rate base to cover upfront costs. Because of this, the MLCC suggests utility programs with new financing mechanisms that enable cost-sharing between the system customers and the utility. For example, the majority of Framingham's TEN costs have come from behind-the-meter construction, including appliance installation, electrical upgrades, and abatement of environmental hazards[36]. In contrast, a Boston Housing Authority (BHA) pilot in Dorchester will have National Grid fund the borefield and loop while BHA funds all behind-the-meter work. The MLCC sees three potential strategies including (1) authorizing utility pilots with public building owners paying for behind the meter upgrades, (2) mandating utility pilots in public buildings, and/or (3) utility-owned TENs paid for by large campus customers.

CLEAResult and WFI noted the importance of accessing operating data from heat pumps to demonstrate the benefits of TENs in pilot applications. CLEAResult noted that TEN owner access to private user data must be planned prior to project execution.

WFI and IDEA recommend starting with smaller pilots. IDEA specifically believes that pilots should demonstrate 3 concepts: a range of thermal network designs (beyond ambient loops), a variety of business models (variety of ownership models), and that pilots should

[36] "Case Study: Framingham, Massachusetts." Building Decarbonization Coalition, https://buildingdecarb.org/resource/case-study-framingham-massachusetts

track “shadow rates” to quantify thermal service rates. BH also believes that pilots in Maine should go beyond UTEN models to look at other campuses, towns, and cities.

Sierra Club recommends immediately implementing a full TEN program, representing that TENs are beyond the pilot stage, due to demonstrated success across the U.S. and internationally. The Sierra Club included reference to eight states that have set up regulatory frameworks for TENs. The policies enacted in three Northeast states are summarized in Table 5.[37]

Table 5: Regulatory frameworks for TENs in select Northeast states, adapted from climatepolicydashboard.org

State	Statutes	Summary
Massachusetts	S.9 (2021); H.5060 (2022); S.2967 (2024)	Gas utilities are allowed to pilot networked geothermal (TENs) projects, and provides a mechanism for approval of rate recovery. Addresses the utility “Obligation to serve” by allowing gas utilities to sell and distribute non-emitting thermal energy instead of natural gas. TENs pilots can be paid for with funds from the state’s pipe replacement program, known as the Gas System Enhancement Plan
New York	S 9422 (2022); CASE 22-M-0429 (2024); S 3004D (2025)	Required the Public Service Commission to order the largest gas and electric utilities to propose TENs pilot projects and establish a regulatory framework for approving and funding TENs.

[37] “Thermal Energy Networks.” State Climate Policy Dashboard, https://www.climatepolicydashboard.org/policies/buildings-efficiency/thermal-energy-networks

State	Statutes	Summary
		The Public Service Commission adopted initial Utility Thermal Energy Networks (UTENs) rules in 2024. The 2025-2026 budget allocated $200 million for TENs projects across the state.
Vermont	Act 142 (2024)	Municipalities in Vermont are authorized to build and operate thermal energy networks without the need for approval or regulation from the Public Utility Commission (PUC). Existing utilities, businesses, developers, co-ops, and non-profits are able to operate their own TENs, subject to PUC authorization. The PUC must publish a report on how to support the development and permitting of TENs by December 1, 2025.

Regarding the question of whether Maine should pursue a pilot, the Sierra Club noted that PCAT believes that two Portland buildings could be good sites for a potential pilot: the Department of Public Works (80,713 square feet) and Parks and Recreation Facilities (68,730 square feet). These buildings are adjacent to several other commercial buildings that could be connected to an expanded TEN in the future. The Sierra Club suggested that Central Maine Power's (CMP's) involvement in a TEN pilot application may be an important aspect of marketing the technology.

Comments provided by WFI and CLEAResult both stated that rate structures that ascribe value to the benefits of TENs can make them more attractive for both developers and business owners. WFI noted that costs should be recovered at a rate that can be reconciled with coincident savings.

Life-Cycle Costs and Benefits

Respondents were asked to provide information on life-cycle costs and benefits of commercially available or emerging thermal energy network technologies, including comparisons to incumbent heating and cooling technologies appropriate for the Maine climate.

Multiple respondents noted the high upfront costs of TENs, but also that the technology has been proven to be more cost efficient with demonstrated payback periods that can be less than 10 years, as referenced by BH. BH also included their view that current low natural gas prices are impacting life-cycle cost comparisons as they can deflate business as usual (BAU) scenario costs. These scenarios do not factor in the lifetime costs of maintaining a natural gas system, which might experience price increases due to global market fluctuations. BH argued that this means TENs will likely require public support, mandates, and utility incentives to encourage long-term investments.

Multiple respondents noted their belief that a GSHP, as opposed to ASHP, may require less maintenance, may have a longer useful life of over thirty years,[38] and may be less susceptible to external fouling and corrosion of outdoor heat exchangers. According to these respondents, such factors could improve long-term efficiency and reduce maintenance costs. WFI noted that the equipment for TENs is extremely durable. They note that closed loop ground heat exchangers and surface water closed loops should last more than 100 years. They are made of the same material as natural gas loops which the natural gas industry typically depreciates over 80 years. TEN infrastructure has the added benefit of transporting water, not pressurized gas. WFI referenced a loop at the WaterFurnace factory in Fort Wayne, IN (which has ambient temperatures of -20° F to 100° F) that has been in operation for over 30 years requiring zero maintenance.

Multiple respondents also suggested that GSHP systems may be more resilient to large swings in outdoor temperatures. In addition, respondents indicated that GSHPs may lower electrical upgrade costs, as they believe electrical service upgrades are generally driven by the increased winter peak from ASHP.

[38] Efficiency Maine's Retail/Residential Technical Reference Manual provides a useful life of ASHPs ranging from 17-25 depending on the configuration and program. Both central ASHP (ducted) systems and central GSHP systems have a useful life of 25 years. For more information, please see: https://www.efficiencymaine.com/docs/EMT-TRM_Retail_Residential_v2026.2.pdf

IDEA recommends sector-coupled integrated resource planning (SCRIP) to evaluate natural gas, electric, and thermal infrastructure holistically. This process would be triggered when a natural gas utility proposes a significant infrastructure repair, replacement or expansion and would consider the most cost-effective alternative.

Solen Works highlighted additional benefits of TENs, including air and water quality improvements, resource conservation, and the embodied carbon of installed materials (e.g., pipes).

Electric Grid Impacts

Respondents were asked to provide information on potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure.

IDEA notes that requiring TENs to have zero reliance on fossil fuels will negatively impact the economics of projects. Conventional technologies for peaking or backup capacity can result in substantial capital savings. IDEA noted the ability to implement a phased approach to reach 100% zero fuels over time. To demonstrate the point, IDEA presented four hypothetical scenarios for TEN service to a mixed-use collection of new buildings totaling 2.2 million square feet of area: (1) TEN with heat pump capacity 100% of peak, (2) hybrid TEN with heat pump as 40% of peak, (3) 100% ASHP, and (4) BAU (i.e., natural gas). Peak power demand for the hybrid TEN is 40% lower than for the 100% heat pump TEN. Compared with the building-based decarbonization strategy (i.e., all ASHP scenario), the hybrid TEN reduces peak power demand by 77%. Emissions scale across the four scenarios.

Almost all respondents highlighted the beneficial grid impacts of TENs, noting that a GSHP can reduce peak demand compared to an ASHP, and that TENs can further benefit the grid through the utilization of thermal banking or thermal energy storage (TES). Most respondents also reiterated the key consideration of leveraging a system with varied thermal loads to smooth demand. Various studies were cited, including:

- The Sierra Club referenced a Synapse Energy Economics study[39] on partially substituting TENs for air-source heat pumps, which found that the winter demand curve could be greatly shaved and that annual benefits measured in billions could

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[39] "Benefits of Thermal Energy Networks: A Comparison to Air-Source Heat Pumps." Synapse Energy Economics, January 29, 2025, https://www.synapse-energy.com/sites/default/files/Benefits%20of%20Thermal%20Energy%20Networks%20Presentation%2024-119.pdf

be achieved across the New England states. This conclusion is based on (1) scaling thermal networks up to 1,500 systems and (2) projected avoided costs of transmission system expansion/upgrades that could be realized by reducing peak demand. Synapse estimates that each thermal network creates $1.3M-$3.5M in benefits over 50 years.

- BH referenced an Oak Ridge National Lab study[40] that found that mass adoption of ground-source heat pumps can reduce transmission and distribution (T&D) expenses by hundreds of billions and see savings of $3/MWh by 2050 nationwide (assuming a BAU scenario without massive increases in demand due to data centers). This conclusion draws on a scenario in which geothermal heat pumps are gradually adopted across the building stock, rising from no deployment in 2021 to full adoption among eligible buildings by 2050. Under this trajectory, roughly five million units would need to be installed annually. The scenario also assumes that new construction begins incorporating geothermal heat pumps starting in 2022, with energy-saving performance comparable to that expected in retrofitted buildings.
- Calculations performed by GeoExchange leveraging NLR state-level data suggest that a ground-source heat pump installation can reduce peak demand by more than 10kW per home in the winter compared to cold-climate air source heat pumps, yielding over $40,000 in lifetime grid benefits per system. This means that TENs can be even more efficient than individual GSHP installations. Additional metrics noted by GeoExchange include avoided costs for 100,000 installations of GSHP, summer grid benefits of $256 million (AESC counterfactual) and winter grid benefits of $4.6 billion (ISO-NE), customer savings of $680 million compared to ENERGY STAR ASHP, and emissions savings of $66 million.
- GeoExchange included two additional studies, conducted by Brattle for Rhode Island (2020)[41] and NYSERDA (2019)[42] which reference the grid benefits of GSHP through relieving constraints and cost reductions.

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[40] "Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States." Oak Ridge National Laboratory, November, 2023, https://info.ornl.gov/sites/publications/Files/Pub196793.pdf

[41] "Heating Sector Transformation in Rhode Island." The Brattle Group, May 27, 2020, https://energy.ri.gov/sites/g/files/xkgbur741/files/documents/HST/RI-HST-Final-Pathways-Report-5-27-20.pdf

[42] "New Efficiency: New York Analysis of Residential Heat Pump Potential and Economics." New Your State Energy Research and Development Authority, January, 2019, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

- IBEW 1253 referenced a DOE study which notes that TENs can reduce energy consumption by 25-50%[43] and WFI noted that GSHP can reduce peak load cooling by 0.6 kW per installed ton of capacity. GeoExchange calculations found that GSHPs require 1.06 kW per ton of cooling and 2.0 kW per ton of heating vs. 0.65 and 0.97 for GSHPs meaning GSHPs save 40% peak usage at 95° F and more than 50% peak usage at 5°F.

WFI also noted that typical ASHPs are installed with electric strip backup systems to provide capacity at low temperatures and offset the cooling delivered during defrost cycles. WFI notes that electric heaters in Maine range from 7.5 to 30 kW for 2-5 ton systems. Because most ducted heat pumps in Maine operate with 30 or 60 minute defrost cycles selected by the installers, the grid is routinely impacted by 2-5 times the typical expected load of a heat pump at times that can be particularly challenging for the grid (i.e., extreme cold). In contrast, BH referenced a case study in Whisper Valley (see Table 2) where a TEN lost power during a cold snap, but the system was able to maintain temperatures without spiking electrical consumption.

Solen Works emphasized the importance of flexible interconnection to TEN success, noting that TENs are ideal candidates due to their inherent thermal storage capacity and load flexibility. GSHPs have thermal storage in the ground itself. The thermal mass of buildings connected to a TEN provides 12-24 hours of thermal inertia. Solen Works notes that this storage enables pre-heating or pre-cooling during off-peak periods when grid capacity is abundant and electricity prices are low, building up thermal reserves before anticipated constrained periods.

Considerations for Statutory Emissions Reduction Goals

Respondents were asked to provide information on the suitability of thermal energy network technology for helping to meet Maine's statutory emissions reduction requirements.

BH noted that TENs have been shown to decrease CO_2 emissions to 10% of that of BAU (i.e., gas heating and electric cooling) and can achieve full decarbonization with the connection to a renewable grid. GeoExchange referenced the ability of GSHPs to reduce emissions by 85-90% compared to conventional fossil fuel HVAC systems.[44]

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[43] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[44] "Clean Energy 101: Geothermal Heat Pumps." Rocky Mountain Institute, March 29, 2023, https://rmi.org/clean-energy-101-geothermal-heat-pumps/

Labor and Workforce Considerations

Respondents were asked to provide information on labor and workforce needs associated with developing thermal energy networks in Maine, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations.

The Sierra Club highlighted the potential that TENs can provide in the transition of the existing workforce and translatable skills. MLCC's comments stated that Maine should "ensure widely-accepted, reasonable, and appropriately high labor standards on TENs to establish a pipeline of work for a trained workforce and ensure workers are not left behind." This would include requiring the use of certified pre-apprenticeship programs, operator qualification standards similar to the natural gas industry, and could include specific licensing requirements. The MLCC referenced New York's UTEN legislation[45] as having effective standards to prioritize the utilization of skills in the incumbent gas utility workforce.

WFI recommends International Ground Source Heat Pump Training (IGSHPA) curricula.

BH included their opinion that TENs can create extensive economic benefits, claiming that TENs can create upwards of 5 skilled jobs for every $1 million spent. Multiple respondents noted that ensuring high labor standards also enhances access to federal tax credits.

Funding Opportunities and Cost Recovery Mechanisms

Respondents were asked to provide information on funding opportunities and cost recovery mechanisms, including, but not limited to (1) leveraging applicable tax credits and other federal assistance, (2) funding from the New England Heat Pump Accelerator, (3) the Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128, and (4) rebates for heat pumps through the Efficiency Maine Trust.

TENs remain eligible for the federal Section 48 investment tax credit following the passage of H.R. 1; however, the bill sunsets the residential clean energy credit for residential geothermal heat pump owners. H.R. 1 does allow for leasing of geothermal heat pump equipment under section 48. According to GeoExchange, these changes will likely lead to TENs system owners proposing to retain ownership of the heat pump equipment for the duration of any tax credit recapture period. As the MLCC noted, tax credits are enhanced by meeting prevailing wage, apprenticeship, domestic content and energy community requirements. MLCC stated that some states have mandated that utilities maximize federal

[45] "Senate Bill S9422." The New York State Senate, June 5, 2022, https://www.nysenate.gov/legislation/bills/2021/S9422

funding opportunities to limit ratepayer impacts. CLEAResult noted the importance of policies that benefit multi-owner/building level investments to support TENs.

IDEA proposed a model (i.e., Ten Value to Power Grid) where the TEN operator is compensated for the value of avoided capital investment in electricity generation, transmission and distribution infrastructure, and the projected life-cycle energy, operation and maintenance costs avoided by the electric utility. These costs would become part of the electric utilities' base rates. IDEA also recommends that for TEN systems partially financed by revenues generated from a regulated gas utility rate base, the portion of the financing supported by the rate base would be paid back to the gas utility as the TEN system grows and reaches specified financial benchmarks.

Multiple respondents, including the MLCC, noted the potential for "inclusive utility investment programs" whereby behind-the-meter upgrades to facilitate TENs are recovered over time using demonstrated energy savings. The MLCC also referenced several states that have established grant and low-interest loan programs to facilitate TEN development including Illinois[46], New York[47], Colorado[48], and Connecticut[49].

The Sierra Club introduced the idea of expanding the Thermal Energy Investment Program administered by EMT, which provides loans for projects utilizing biomass to produce heat, to encompass TENs.

Affordability of Housing, Development, and Energy

Respondents were asked to provide information on the role thermal energy networks can play in increasing the affordability of housing, development and energy.

GeoExchange included affordable housing development demonstration projects that have been completed or are underway in states such as Michigan,[50] Colorado,[51] New York,[52]

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[46] Illinois Finance Authority/Climate Bank. Climate Pollution Reduction Grant Community Geothermal Planning + Pilots program.
[47] NYSERDA. Large Scale Thermal Program.
[48] Colorado Energy Office. Geothermal Energy Grant Program.
[49] Connecticut. Thermal Energy Network Grant and Loan Program.
[50] "Everything you need to know about affordable housing at 121 Catherine St." The Michigan Daily, February 19, 2024, https://www.michigandaily.com/news/ann-arbor/everything-you-need-to-know-about-affordable-housing-at-121-catherine-st/
[51] "Willoughby Corner, a New 400-Unit Affordable Housing Development in Lafayette." Colorado Construction and Design, https://ccdmag.com/project-updates/willoughby-corner-lafayette/
[52] "Housing Authority recognized for geothermal work." Union Sun and Journal, https://www.lockportjournal.com/news/local_news/housing-authority-recognized-for-geothermal-work/article_17ea7655-8d2c-5556-b1b8-b56574069e89.html

Massachusetts,[53] and Wisconsin.[54] Multiple respondents noted that the long lifespans and minimal maintenance required for TENs make them stable and cost-effective, WFI found that a typical family of four can see heating, cooling, and hot water monthly savings of $100-$250 and due to extended equipment lifespan, can save a re-investment of $12,000-20,000 every 10-15 years. MLCC also noted that the grid benefits of TENs have large-scale benefits for all ratepayers and CLEAResult emphasized the local economic and workforce benefits of TEN installations.

Additional Considerations

Respondents were asked to provide information on additional considerations including (1) technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks, (2) lifetime and annual project cost-effectiveness, including assumptions, of TENs (3) explain the applicability, benefits, challenges and scalability of thermal energy networks to various geographic regions in Maine (e.g., urban, rural, remote, etc.), (4) outline any considerations for new construction or retrofit projects adopting networked geothermal, (5) the safety, reliability, and resiliency of TENs during both normal operations and during outages or extreme weather, and (6) utility ownership, regulatory and cost allocation/recovery frameworks that may be applicable to thermal energy networks, including frameworks that currently exist in Maine law.

Alternative or Companion Solutions

CLEAResult and WFI both noted the high heating to cooling ratio in Maine (9:1), meaning it would likely make financial sense to supplement TENs with external heating sources to reduce cost and complexity. Small scale waste digesters, passive solar water heating, or wastewater heat exchangers were presented as potential solutions. The Sierra Club noted that battery energy storage system could be a logical addition, potentially designed as a virtual power plant. In retrofit situations, CLEAResult noted that a hybrid approach between TENs and conventional design, with a phased approach, might yield optimal cost and energy savings.

IDEA noted that the RFI definition only includes ambient loop TEN systems (i.e., a heat pump located in the building). The definition ignores systems that distribute thermal energy to buildings via a network of pipes (i.e., district energy system). Ambient loop systems are

[53] “Healey-Driscoll Administration Awards $27 Million to Decarbonize Affordable Housing Across Massachusetts.” Office of Massachusetts Governor Maura Healey, November 21, 2023. https://www.mass.gov/news/healey-driscoll-administration-awards-27-million-to-decarbonize-affordable-housing-across-massachusetts

[54] “Prairie Heights Residences Opens in Eau Claire.” West Cap, July 11, 2025, https://westcap.org/2025/07/prairie-heights-residences-opens-in-eau-claire/

generally more expensive than district energy systems due to additional maintenance of heat pump technology and are still relatively untested.

Lifetime and Annual Cost-Effectiveness

WFI stated that behind-the-meter single-family property should generate annual savings between $1,000-$3,000 but emphasized that lifetime benefits are dependent on the time window used in the calculation. Monetizing a more finely tuned estimate of behind-the-meter savings vs. front-of-meter costs is the simplest way to estimate financial efficacy.

Geographic and Location Considerations

Solen Works cited multiple case studies (see Table 2) which demonstrate (1) consistent technical performance with heat pump coefficients of performance of 3.0 to 5.0 and (2) greenhouse gas reductions of 25 to 80 percent versus fossil fuel baselines in climates comparable to or more severe than Maine's and (3) use of thermal resources Maine possesses in abundance. WFI referenced Maine’s more than 1,500 miles of natural gas pipelines and 100,000 miles of water pipelines, noting that if these pipelines can be established then there is some economic viability for TENs. WFI claims that while these existing pipelines cannot be directly repurposed for TENs, if there is sufficient density to allow customers to be served by natural gas or water pipelines economically, then similar conditions exist for these customers to be served by TEN pipelines.

New Construction or Retrofit Considerations

CLEAResult outlined that the primary systemic barriers for TENs are non-technical, including (1) high upfront costs, (2) split incentives between developers and owners/tenants, (3) financing and valuation gaps making it difficult to accurately assess future energy savings, (4) utility and regulatory barriers, (5) coordination challenges for shared systems, and (6) lack of regulatory clarity.

WFI noted that not all retrofits are standardized and generally a modern home building will be easier than an uninsulated 100-year-old wood frame house with no ductwork. Retrofit projects should balance addressing most expensive or polluting heating sources and cost and complexity.

Safety, Reliability, and Resiliency Considerations

WFI highlighted that TENs require electricity, so there can be some reliability concerns during an outage which could be mitigated with storage. However, WFI believes that TENs are extremely resilient to fires, floods, and extreme heat and cold. WFI notes that beyond 10 meters depth, Maine’s soil, lakes, and coastal waters are a nonintermittent source of renewable energy.

Ownership, Regulatory, and Cost Recovery Frameworks

WFI noted that it is likely that the first pilot projects are not cost effective. There might be a need, like in Framingham, to pay for behind-the-meter enabling upgrades as well as for the TEN itself. The Sierra Club strongly favors an ownership model where customers served by the TEN have ownership (i.e., rural co-op model). Under this proposed model, the TEN co-op initially starts with one project, then expands as needed to develop into a utility co-op serving TENs across the state. In this model, the TEN co-op is distributed rather than localized like rural electrical co-ops.

Additional Information

Respondents were asked to provide information on any additional information relevant to the scope of the RFI.

Solen Works and the Sierra Club recommend moving beyond minimum viability function pilots. The Sierra Club advocates for the DOER to create, in conjunction with other relevant Maine state agencies such as EMT, a meaningful program based on responses to this RFI. to hasten the development of TENs in Maine. Solen Works believes that pilots must be excellent demonstrations that are designed, properly commissioned, comprehensively monitored, and generate compelling data to support scaling.

Recommendations

The recommendations in this report reflect the information received through the RFI and emphasize the importance of continued learning as the next steps related to TENs are considered in Maine. The next steps should be informed by ongoing and forthcoming state studies, including the Geothermal Power Plant Opportunities Study (L.D. 300), and should prioritize structured scoping work to clarify the role these systems could play within particular sectors in Maine as well as Maine's broader energy strategies. Key themes include:

- **Continue Building the Information Base:** TENs represent a potential option for reducing building emissions and system impacts of heating; however, available information regarding specific costs, best practices, and site feasibility is limited. Additional data and analysis are needed to better understand the most beneficial types of applications in Maine. The RFI did not receive direct participation from electric or gas utilities and no responses from entities that have themselves implemented TEN pilots in comparable cold-climate regions. Robust operational and cost-benefit data from these entities will be critical. Additional engagement with trusted organizations producing emerging guidance and best practices, such as the National Association of State Energy Officials (NASEO) and NLR, could also help address current information gaps.

- **Engage with Experienced Implementers:** Further outreach to developers, utilities, campus operators, and public entities that have implemented TEN projects and pilots – particularly in cold-climate regions – would provide valuable insight into system performance, costs, and operational considerations. Consider working with project implementers to gain access to operational data and cost information where it isn't publicly available and identifying a framework for evaluating pilot data in a consistent and comprehensive manner.
- **Differentiate Applications by Project Type:** Application of TENs in new construction developments may offer different opportunities and challenges compared with retrofit applications. More information is needed to understand how the different cost and technical considerations of these approaches compare. While new construction (e.g., campuses or coordinated multi-building developments) may allow for more efficient, integrated system design, retrofit applications may involve higher and more variable costs and could require phased development approaches, making careful site screen and cost analysis particularly important. Working to develop a site screening tool could prove useful in identifying the most promising locations for potential pilots.
- **Clarify Regulatory and Coordination Considerations:** Early attention should focus on understanding coordination needs, permitting considerations, available cost-sharing methodologies, and stakeholder roles, rather than on developing new regulatory frameworks. A review focused on identifying major uncertainties – such as cost allocation and roles among participants – could help reduce friction for early demonstration or pilot projects.
- **Leverage External Resources and Ongoing Research:** Monitor emerging guidance, best practices, and federal assistance opportunities and resources including low-cost technical assistance from trusted organizations such as DOE's national laboratories to help inform future decision-making regarding policy interventions while limiting near-term risk. This may include federal planning support, technical assistance, and financial or tax incentives, as well as public-private partnerships or collaboration with utilities that could help reduce upfront costs and risks for initial pilots.
- **Account for Workforce Considerations:** Workforce and training considerations should remain part of early planning to ensure training and credentialling requirements are aligned and ensure that Maine's workforce is prepared if a market for thermal network deployment emerges in Maine. Early alignment of training

programs, credential pathways, and labor standards could help position skilled trades and technical professionals to participate in future TEN development.

Overall, these recommendations emphasize continued evaluation of existing public and privately developed projects and pilots to identify the most promising applications for TEN development in the Maine context. This approach is intended to support practical, informed, and cost-effective next steps that are aligned with the state's long-term energy goals.

Appendix

Text of Resolve

Resolve, to Direct the Governor's Energy Office to Solicit Information Regarding the Creation of a Thermal Energy Networks Program in Maine

STATE OF MAINE

IN THE YEAR OF OUR LORD

TWO THOUSAND TWENTY-FIVE

H.P. 1073 - L.D. 1619

Resolve, to Direct the Governor's Energy Office to Solicit Information Regarding the Creation of a Thermal Energy Networks Program in Maine

Sec. 1. Request for information. Resolved: That the Governor's Energy Office shall, within existing resources, issue a request for information regarding the creation of a thermal energy networks program in the State. For the purposes of this resolve, "thermal energy network" means a system of interconnected piping that circulates thermal transfer water for the purpose of providing low-emissions heating and cooling to 2 or more buildings through the use of water source heat pumps at each building connected to the system. The primary thermal energy source for such a network may include, but is not limited to, geothermal resources or recovered thermal energy, such as waste heat captured from buildings or wastewater systems. When issuing the request for information, the office shall solicit information from stakeholders regarding:

1. Any relevant available research, framework, pilot projects and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;

2. The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:

A. Geophysical considerations;

B. Compatibility with incumbent air source heat pumps and other heating, ventilating and air-conditioning systems;

C. Permitting and right-of-way considerations;

D. Constraints around geographic density; and

E. Other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks;

3. Recommended processes for facilitating and encouraging thermal energy networks pilot projects, including ownership structures and cost recovery mechanisms;

4. Life-cycle costs and benefits of thermal energy networks, including comparisons to incumbent heating and cooling technologies;

5. Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

6. The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals;

7. Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified preapprenticeship programs;

8. Funding opportunities and cost recovery mechanisms, including, but not limited to:

A. Leveraging applicable tax credits available under the federal Inflation Reduction Act of 2022 and other federal assistance;

B. Funding from the New England Heat Pump Accelerator;

C. The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and

D. Rebates for heat pumps through the Efficiency Maine Trust; and

9. The role thermal energy networks can play in increasing the affordability of housing, development and energy.

Sec. 2. Report. Resolved: That the Governor's Energy Office shall prepare, in consultation with the Efficiency Maine Trust and the Public Advocate, a summary report regarding the information received by the office in accordance with section 1 and, by January 15, 2026, submit the report to the Joint Standing Committee on Energy, Utilities and Technology. The office may develop and include in the report recommendations regarding the development of a thermal energy networks program in the State. The joint standing committee may report out a bill to the Second Regular Session of the 132nd Legislature based on the report.

Request for Information

Maine Governor's Energy Office/Maine Department of Energy Resources
Request for Information
Regarding Thermal Energy Networks Pursuant to Resolve 2025, ch. 67

Issue Date:	September 18, 2025
Subject:	Request for Information Regarding Thermal Energy Networks Pursuant to Resolve 2025, ch. 67 (L.D. 1619)
Response Due Date:	October 17, 2025
Submit Responses To:	doer@maine.gov with the email subject line "Thermal Energy Network RFI"

Description

This is a Request for Information (RFI) issued by the Governor's Energy Office (GEO)/Maine Department of Energy Resources (DOER).

The purpose of this RFI is to solicit information regarding the potential creation of a "thermal energy networks program" for Maine, pursuant to Resolve 2025, chapter 67, *Resolve, to Direct the Governor's Energy Office to Solicit Information Regarding the Creation of a Thermal Energy Networks Program in Maine* (L.D. 1619 or the Resolve),[55] which was signed into law by Governor Janet Mills on June 11, 2025.

Section 1 of the Resolve directs the GEO to solicit information regarding the creation of a thermal energy networks program in Maine, including, but not limited to, relevant frameworks and pilots, information about costs, feasibility and applicability, recommended processes, life-cycle analyses, electric grid impacts, relevance to Maine's statutory emissions reductions goals, labor considerations, and impact on affordability of housing development and energy. For the purposes of this RFI, "thermal energy network" is defined per the Resolve as 'a *system of interconnected piping that circulates thermal transfer water for the purpose of providing low-emissions heating and cooling to 2 or more buildings through the use of water source heat pumps at each building connected to the system*.' Per the Resolve, the primary thermal energy source for such a network may include, but is not limited to, geothermal resources or recovered thermal energy, such as waste heat captured from buildings or wastewater systems.[56]

Section 2 of this Resolve directs the GEO to prepare, in consultation with the Efficiency Maine Trust (EMT) and the Office of the Public Advocate (OPA), a summary report regarding the information received in response to the RFI and, by January 15, 2026, to submit the report to the Joint Standing Committee on Energy, Utilities and Technology. GEO may

[55] Resolve 2025, Chapter 67 (June 11, 2025).
[56] Ibid.

develop and include in the report recommendations regarding the development of a thermal energy networks program in the State.

Intent of this Request for Information

All interested parties are invited to respond to this RFI.

Respondents may respond to some or all of the following information requests and may provide additional information they believe to be useful to GEO/DOER in meeting its obligations under the Resolve, regarding the development of a thermal energy networks program in the State.

GEO/DOER requests written public comments on the following topics as called for by the Resolve. Responses must be in the form of written comments and submitted electronically to doer@maine.gov on or before October 17, 2025, by 4:00 p.m.

1) Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;

2) The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:

   a) Geophysical considerations;

   b) Compatibility with incumbent air source heat pumps and other heating, ventilating and air-conditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network;

   c) Permitting and right-of-way considerations;

   d) Constraints around geographic density; and

   e) Other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks;

3) Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;

4) Life-cycle costs and benefits of commercially available or emerging thermal energy network technologies, including comparisons to incumbent heating and cooling technologies appropriate for the Maine climate;

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

6) The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals[57];

7) Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;

8) Funding opportunities and cost recovery mechanisms, including, but not limited to:

    a) Leveraging applicable tax credits and other federal assistance;

    b) Funding from the New England Heat Pump Accelerator;

    c) The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and

    d) Rebates for heat pumps through the Efficiency Maine Trust;

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

10) Additional considerations including:

    a) Technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks;

    b) Lifetime and annual project cost-effectiveness, including assumptions, of thermal energy networks;

    c) Explain the applicability, benefits, challenges and scalability of thermal energy networks to various geographic regions in Maine (e.g., urban, rural, remote, etc.);

    d) Outline any considerations for new construction or retrofit projects adopting networked geothermal;

    e) The safety, reliability, and resiliency of thermal energy networks during both normal operations and during outages or extreme weather;

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[57] 38 MRSA §576-A

f) Utility ownership, regulatory and cost allocation/recovery frameworks that may be applicable to thermal energy networks, including frameworks that currently exist in Maine law; and

11) Any additional information relevant to the scope of this RFI.

Use of Information

Information collected from this RFI will be used by the GEO/DOER to inform the fulfillment of requirements under the Resolve, and will be provided to the Joint Standing Committee on Energy, Utilities and Technology in a summary report.

This is an RFI only, and the GEO/DOER will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. ***The GEO/DOER may publish responses to this RFI on its website. All responses to this RFI may be subject to the State of Maine Freedom of Access Act,[58] thus sensitive or confidential business information should not be provided in response to this RFI.***

[58] https://www.mainelegislature.org/legis/statutes/1/title1ch13sec0.html.

Submissions to Request for Information in Full

Efficiency Maine Trust (the Trust) appreciates the opportunity to offer comments in response to two of the questions posed in the Thermal Energy Networks Study Request for Information issued by the Department of Energy Resources.

1. ***Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;***

The Trust has been tracking several pilot projects currently underway in other states in the Northeast and recommends further close examination of their results. These pilots can provide valuable data and insights (at little or no cost to Maine) to better understand if thermal energy networks have promise for consumers in Maine.

From our initial reviews, these pilots already shed light on critical questions about cost/affordability and technical feasibility. The type of questions that these pilots might help answer include:

a. Have project costs (infrastructure, equipment, labor, operation, etc.) remained consistent with initial estimates?
b. Did pilots encounter any unexpected challenges that delayed or significantly impacted the pilot design and costs?
c. How were pilot costs reconciled by the utility and what will this do to affordability for utility ratepayers?

The closest pilot, geographically, and one that has progressed sufficiently to provide real-world results on costs and benefits, is the thermal energy network project in **Framingham, Massachusetts**. This project was first approved by the Massachusetts Department of Public Utilities (DPU) in October 2020.

In the DPU's Order approving the project, which provides heating to 135 homes, the utility Eversource estimated that "the demonstration project costs could total $14,061,769,65 including the costs of drilling wells, installation of heat pumps, internal labor, in-home equipment (e.g., heat pump units, distribution piping, ductwork)".[1] Four years later, in an August 2024 Geothermal Energy Provision cost recovery filing, the company stated, "Based on progress to date on the Pilot, the Company has developed an updated budget: $27,075,958, of which $24.36 million is associated with the construction of the Pilot".[2]

The Office of Attorney General for Massachusetts filed a brief in response to the cost recovery filing:

> Responsibility for the bulk of the project's cost increase from the initial budget estimate of $10.5 million to the latest Company estimate to complete the project of

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[1] The Commonwealth of Massachusetts Department of Public Utilities, Order, D.P.U. 19-120, October 30, 2020, pg. 129
[2] NSTAR Gas Company d/b/a Eversource Energy, GEP Annual Filing, D.P.U 24-114, August 1, 2024, pg. 13

$27 million has been in system construction costs. The construction includes both the loop and borefields and the installed cost of heating equipment at participating buildings. Dividing total project costs (before claimed tax credits) of $27 million by the number of participating customers (135) yields an average participant cost of the shared system of $200,000 (before claimed tax credits). A better cost comparison would divide the total project cost ($27 million) by the available thermal heating and cooling capacity of the system, (expressed in tons) of 348 tons, which yields an average project cost of roughly $77,500 per ton. This capacity cost, per ton, is several multiples higher than the approved 2025-2027 Statewide Energy Efficiency Plan budgets for installing air source heat pumps as an electrification/decarbonization strategy.[3]

Reviewing what construction costs or other costs caused the total project costs for this Framingham pilot to more than double from the original estimates is important information for Maine to consider when determining if thermal energy networks are a viable option to affordably heat Maine buildings, reduce winter peak demand on the grid, and support reliability.

2. **The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:**

   ...

   b. **Compatibility with incumbent air source heat pumps and other heating, ventilating and air conditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network;**

For the past two years, the Trust has been conducting its own pilot project seeking to demonstrate the performance of air-to-water heat pump technology configured with hydronic (forced hot water) distribution systems. We have learned that there are significant technical challenges. While there are some promising solutions to these technical challenges, some of these solutions add cost to the system (either capital cost or operating costs). These costs can make or break the cost-effectiveness of the solution. The Trust respectfully suggests that future inquiries into whether TEN warrants piloting in Maine consider the following in response to the RFI's question 2b:

i. Can thermal energy networks produce hot enough temperatures to be compatible with the heating distribution systems (forced hot water radiators or forced hot air ducts) that are prevalent in Maine?
ii. If not, are there low-cost ways of retrofitting distribution systems instead of replacing existing systems with new equipment?

[3] The Office of the Attorney General, Initial Brief, D.P.U. 24-114, June 3, 2025, pg. 4

Geothermal Heat Pumps as a Grid Resource

Ryan Dougherty, GeoExchange
Doug Presley, AnnDyl Policy Group

Geothermal Heat Pumps - Overview

- GHPs are the most efficient heating AND cooling systems available
- GHPs are a grid resource – peak reductions of 1-10+ kW per home, avoids new generation, transmission, distribution
- GHP annual customer savings up to $5,000 depending on original fuel
- Current industry highlights:
  - Commercial GHPs remain eligible for 30% federal tax credit through 2034, plus 10% domestic content bonus credit
  - Residential 30% tax credit repealed at end of 2025; leasing now authorized

GeoExchange is a national nonprofit trade that promotes the manufacture, design, and installation of geothermal heating and cooling technologies. Its members include manufacturers, installers, technology providers, and utilities across the country.

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Geothermal (ground source) heat pumps (GHPs or GSHPs)

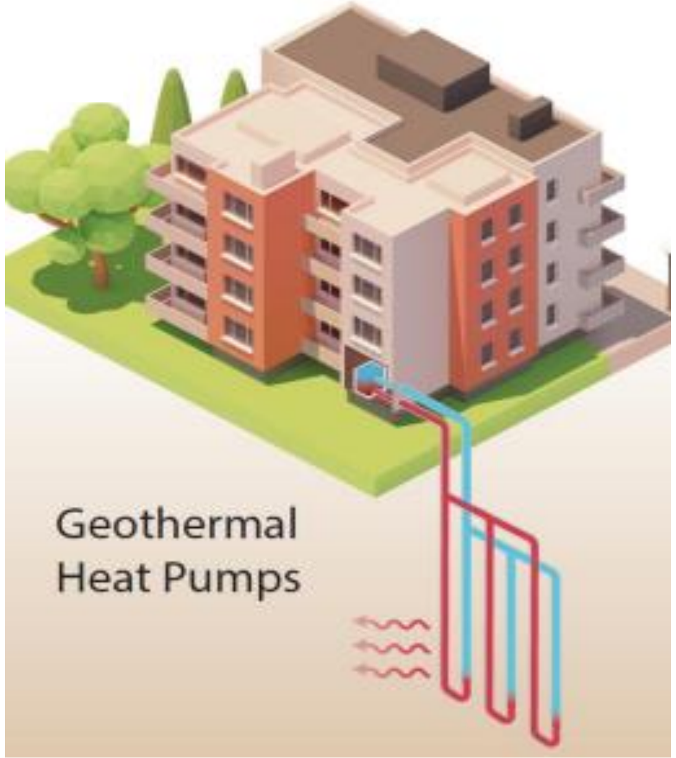
The stable earth temperature makes GHPs the most efficient heating and cooling system available

<u>Most common design (shown)</u>: Vertical boreholes w/ grouted plastic pipe

- Not “wells,” there is no flow in-out of the formation
- Circulate water w/ non-toxic anti-freeze
- Annual energy load sets number and length of boreholes
- Significant cost savings when paired with weatherization

<u>Special design, if site conditions</u>

- Horizontal loops – need large land areas
- Use of ground, surface, or sewer water is also Geo



Source: *Pathways to Commercial Liftoff: Geothermal Heating and Cooling,* U.S. Department of Energy

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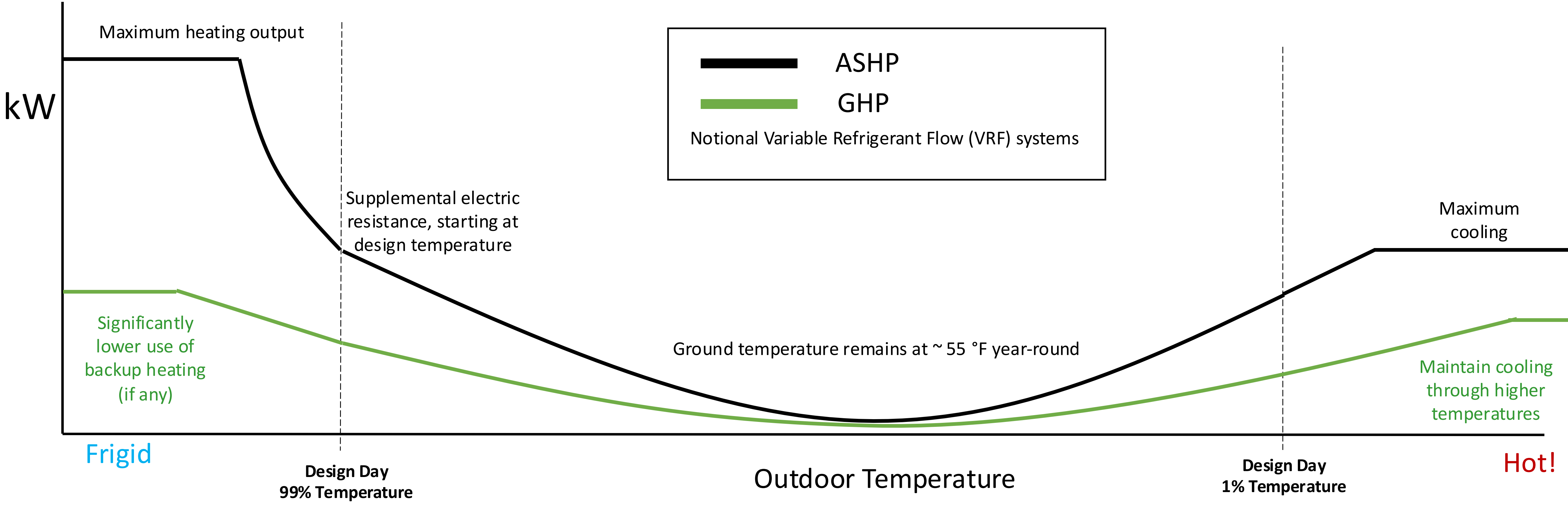
Notional Heat Pump Electric Demand



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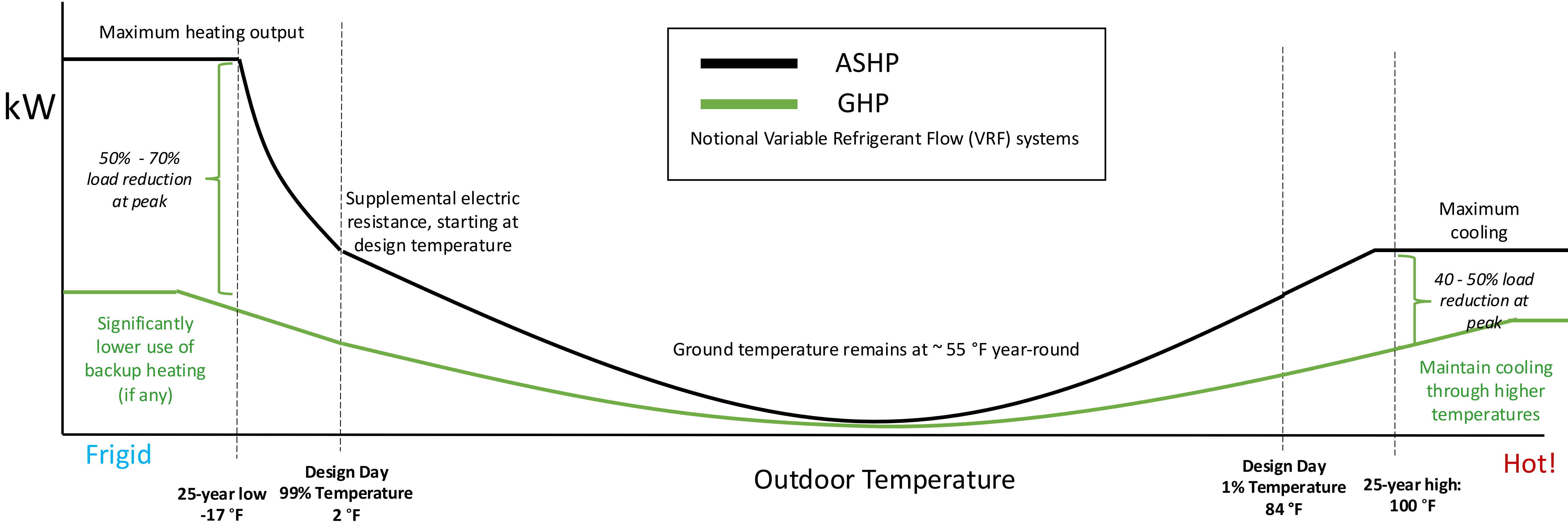
Notional Heat Pump Electric Demand – Portland, ME



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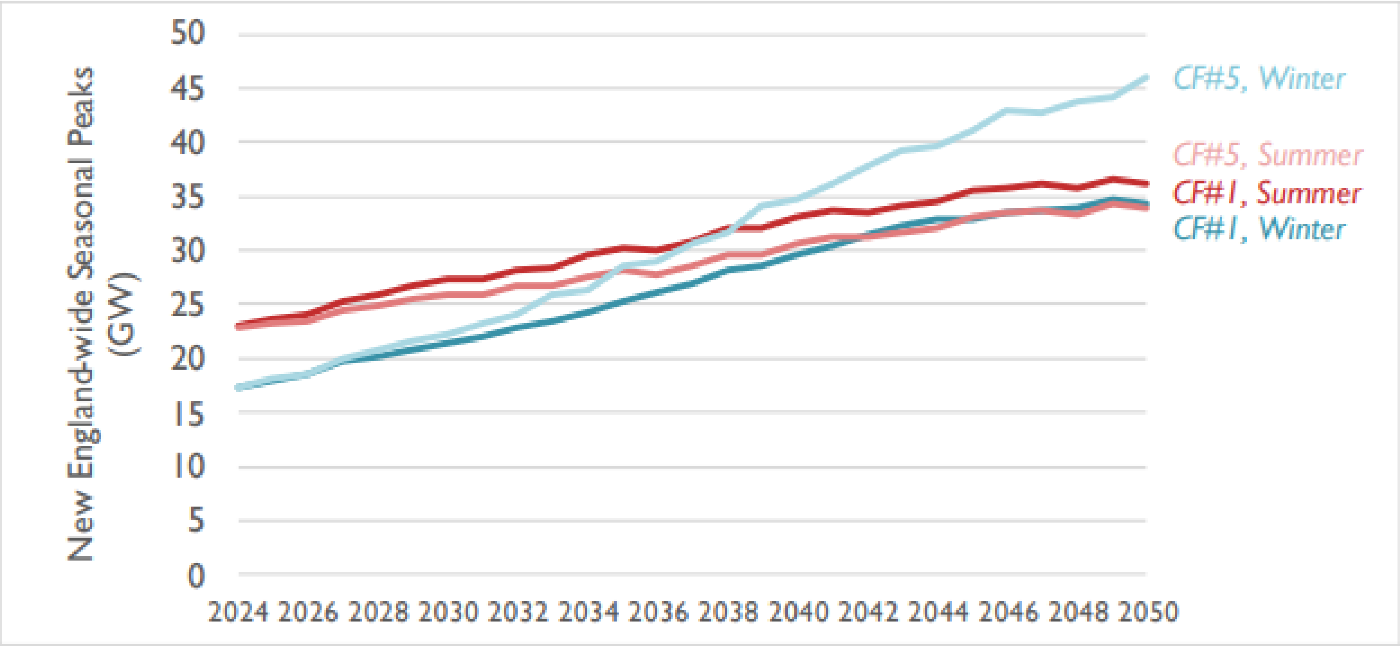
Summer and Winter Peak Demand and Reliability

ISO NE: Risk Level: Elevated; 2026 and beyond: *"Strong demand growth and persistent winter natural gas infrastructure limitations pose risks of supply shortfalls in extreme winter conditions."* – North American Electric Reliability Corporation (NERC) 2024 Long-Term Reliability Assessment

ISO NE shifts to winter peaking grid in ~ 2035 under Counterfactual 5 (includes EE, electrification, and demand management)

Figure 26. Seasonal peak demand forecasts for ISO New England in Counterfactual #1 and Counterfactual #5



Note: Peak demand projections for other counterfactuals can be found in the AESC 2024 User Interface Excel workbooks.

Source: Avoided Energy Supply Components in New England: 2024 Report, AESC 2024 Study Group, May 24, 2024, Synapse Energy Economics

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GHP vs ASHP for Heating and Cooling

Performance of Representative GHPs (4-ton)	COP	EER
ClimateMaster Tranquility SE	4.0 – 4.4	19.4
Dandelion Geo	4.7 – 5.2	17.1
Water Furnace 7 Series	3.4 – 5.1	20.0

Performance of Representative ASHPs (4-ton)	COP @ 5°F	EER
NEEP Cold Climate ASHP	1.75 – 2.1	9.3-11.7
ENERGY STAR ASHP	N/A	11.0

Source: Selected AHRI Directory Listings, NEEP ccASHP Directory

Cooling: GHP demand per ton = 12,000 btu/hr / 18.5 EER
= 649 watts per ton
= 0.65 kW per ton

Heating: GHP demand per ton = 12,000 btu/hr / 3.6 COP
= 3,333 btu/hr per ton
= 0.97 kW per ton

Cooling: ASHP demand per ton = 12,000 btu/hr / 11.3 EER
= 1,062 watt per ton
= 1.06 kW per ton

Heating: ASHP demand per ton = 12,000 btu/hr / 1.75 COP
= 6,857 btu/hr per ton
= 2.0 kW per ton + backup heating

GHP saves 40% peak usage @95°F = 0.4 kW per ton summer peak savings
GHP saves >50% peak usage @5°F = 1.0 kW per ton winter peak savings

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2023 DOE/ORNL Study:
Grid Cost Reduction via Mass Deployment of GHPs

"*Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States*"

- Widespread* deployment of GHPs could save more than $1 trillion in nationwide energy system costs by 2050
  - Up to 345 GW of avoided new generation capacity
  - Avoids between 17% - 38% of new transmission through 2050 – up to 43,000 miles of avoided transmission lines
  - Reduces electric rates by 6%-12%
  - Gas customer annual savings of $19B/year by 2050

*These findings are derived from modeling 68% of all building space being served by GHPs, including 43% of commercial building space and 78% of residential building space

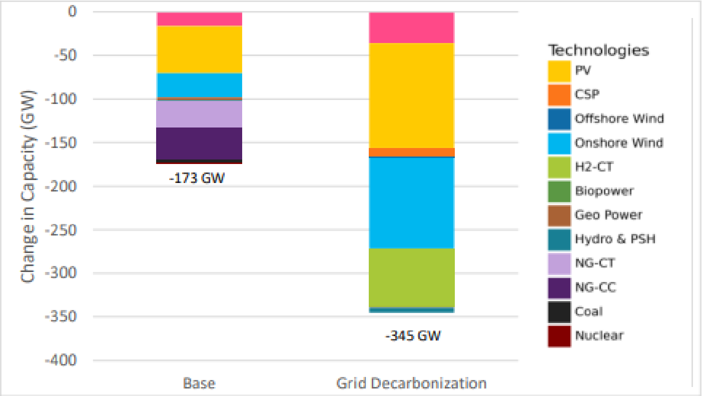

Figure 4-2. Changes in national installed capacity in 2050 (GW) resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base and Grid

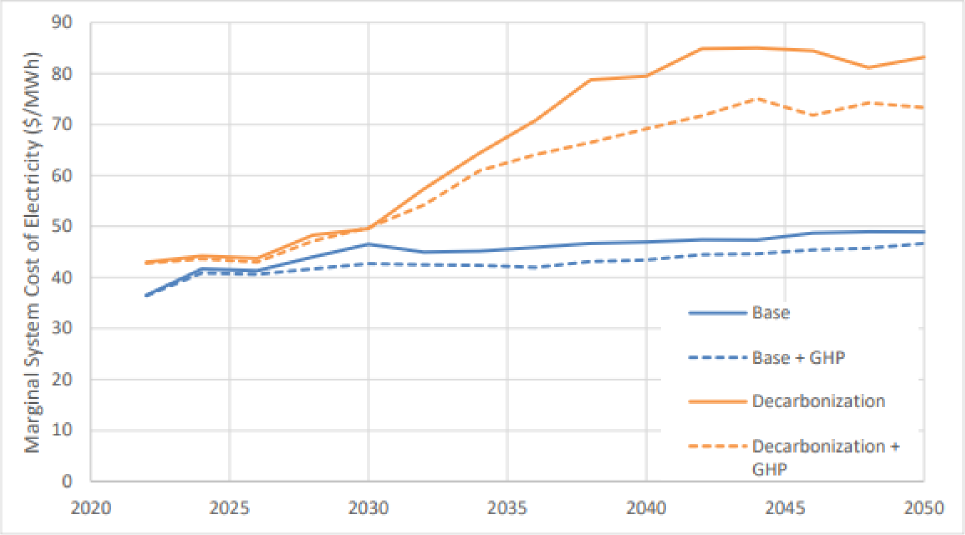

Figure 4-8. National-average marginal system cost of electricity from 2022 to 2050 with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios.

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GHP Benefits – kW and kWh Savings

GHP replacing:	Single-Family Savings - Maine			
	Annual Energy (kWh/kWh_eq)	Summer Peak (kW)	Winter Peak (kW)	Annual Bill Savings ($)
Cold Climate ASHP	2,187	0.5	10.2	$532
ENERGY STAR ASHP	9,786	0.5	11.2	$2,300
Electric Resistance	14,114	0.5	12.8	$4,991
Gas	18,877	0.5	-2.9	-$260 (adds cooling) to $165 (full electrification)

Results from NREL ResStock 2024.2 dataset for 3,000 simulated Maine homes

- Results are conservative – applies to all housing stock, while real-world retrofits are generally to older HVAC systems; uses "typical" weather data, not extreme weather data
- Summer peak modeling uses adjusted value of 0.4 kW/cooling ton; uses Maine utility-specific rates

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Avoided Cost with GHPs vs ccASHP

Typical methodology:

- 2,200 kWh saved * $0.26/kWh (supply + delivery) = $572 / year

Avoided Cost with GHPs vs ASHP

Typical methodology:

- 2,200 kWh saved * $0.26/kWh (supply + delivery) = $572 / year

Full Value-Stack:

Capacity	Fuel	Generation	Ancillary Services	Regional Transmission	Local Distribution (Utility-specific)	Emissions	Health	Environmental
$400 - $700/kW	Fuel savings for customer DRIPE of $75 - $340 for all ratepayers			$133/ kW	$278/ kW	$500 - $4,000		

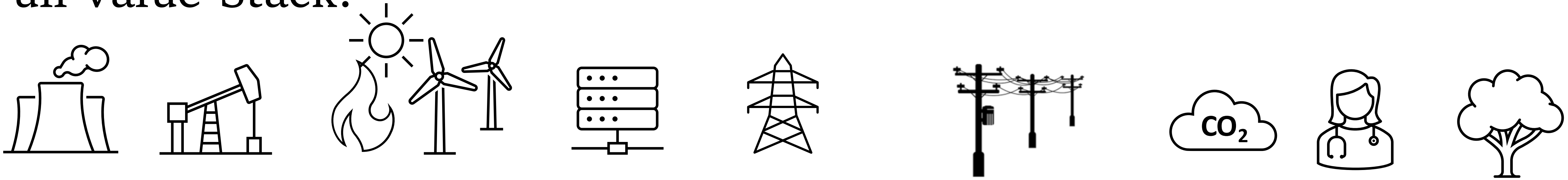
GEOEXCHANGE®

Avoided Cost with GHPs vs ASHP

Typical methodology:

- 2,200 kWh saved * $0.26/kWh (supply + delivery) = $572 / year

Full Value-Stack:



Capacity	Fuel	Generation	Ancillary Services	Regional Transmission	Local Distribution (Utility-specific)	Emissions	Health	Environmental
WoodMackenzie: Up to $2,700/kW for new gas turbine	Fuel savings for customer DRIPE of $75 - $340 for all ratepayers			$133/ kW	$278/ kW	$500 - $4,000		

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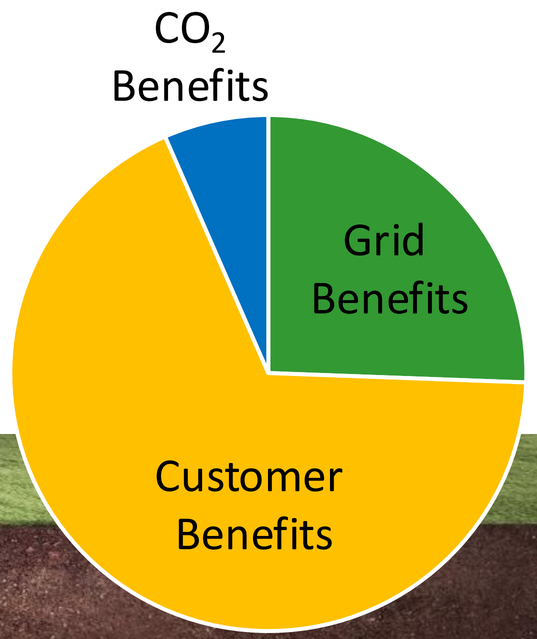
Avoided Cost with GHPs vs ccASHP

- <u>GHP Benefits for 100,000 installations:</u>
  - Grid Benefits (summer): $256 million (AESC Counterfactual 2)
  - Customer savings: $680 million
  - Emissions savings: $66 million(mid)
- Economic and Performance Factors:
  - Peak load reduction / unit vs Cold Climate ASHP: 0.5 kW (summer)
  - Energy savings / unit: 2,200 kWh per year
  - Grid Benefits:
    - Capacity~$350 / kW (PV)
    - Transmission and Distribution: $4,000/kW (PV)
    - DRIPE: $75 per GHP (PV)
  - Financial parameters: ~$0.26/kWh, 25-year system life



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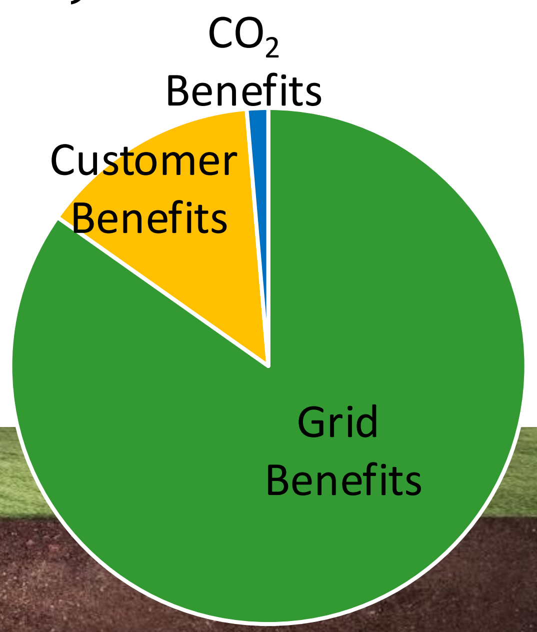
Avoided Cost with GHPs vs ccASHP

- <u>GHP Benefits for 100,000 installations:</u>
  - Grid Benefits (winter): $4.1 billion (AESC Counterfactual 5)
    $4.6 billion (ISO NE Net CONE)
  - Customer savings: $680 million (vs. ENERGY STAR ASHP)
  - Emissions savings: $66 million(mid)

- Economic and Performance Factors:
  - Peak load reduction / unit vs Cold Climate ASHP: 0.5 kW (summer)
  - Energy savings / unit: 2,200 kWh per year
  - Grid Benefits:
    - Capacity~$350 / kW (PV)
    - Transmission and Distribution: $4,000/kW (PV)
    - DRIPE: $75 per GHP (PV)
  - Financial parameters: ~$0.26/kWh, 25-year system life



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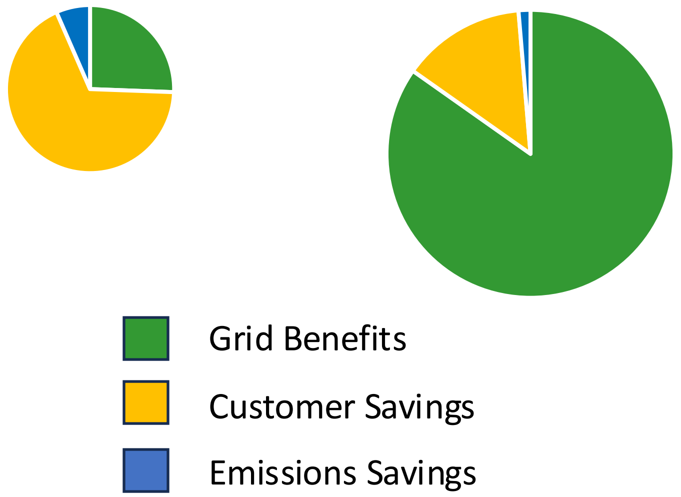
Summary

Benefits of GHP Installation in Portland, ME

Summer – 0.5 kW Peak Reduction

Winter – 10+ kW Peak Reduction



- GHPs are the most efficient heating AND cooling systems available
- GHPs yield annual customer bill savings up to $5,000
- GHPs are a grid resource – especially in the winter
  - 0.5 kW peak savings per home in the summer
  - 10+ kW peak savings per home in the winter
- $40,000+ in grid benefits per GHP system

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Thank you!

We look forward to your questions!

ryan@geoexchange.org

doug@anndyl.com

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Multiple Studies Confirm GHP Grid Benefits

- DOE (2024):
  - *"Significantly reduce overall grid system costs through reductions in capacity, transmission, and other grid maintenance needs associated with peak demand."*
- Brattle for Rhode Island (2020):

	Power Rates	Peak Capacity	Load Factor
ASHP	+13%	+ 36 GW	38%
GHP	no change	+ 7 GW	61%

Source: Brattle *"Heating Sector Transformation in Rhode Island"*
Values for all of New England

- NYSERDA (2019):
  - Residential GHP customers "overpay" their share by $7,000-$14,000; GHPs benefit all ratepayers (even those that don't have one)
- Oak Ridge (1998):
  - Results from widespread adoption of GHPs in the community of Fort Polk, LA
  - 43.5% lower annual electricity use

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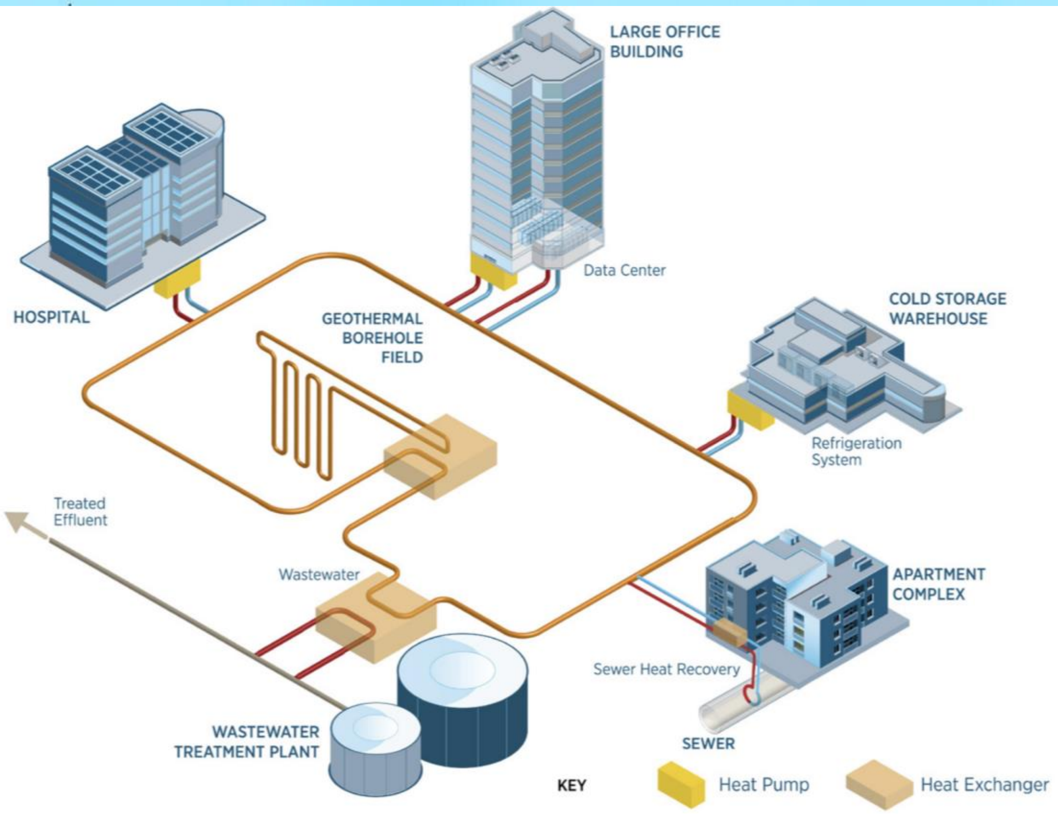
Networked and Neighborhood Geothermal

- Networked geothermal connects a group of buildings through underground pipes, maximizing efficiency
  - Leverage surplus heat from data centers, ice rinks, supermarkets, wastewater, and more
- Neighborhood-scale deployment of individual building systems can achieve similar grid and decarbonization benefits
- Notable projects:
  - Eversource, Framingham, MA
  - Whisper Valley, Austin, TX
  - Norton Commons, KY (individual loop neighborhood)
  - And many more in development!



Source: *Pathways to Commercial Liftoff: Geothermal Heating and Cooling,* U.S. Department of Energy

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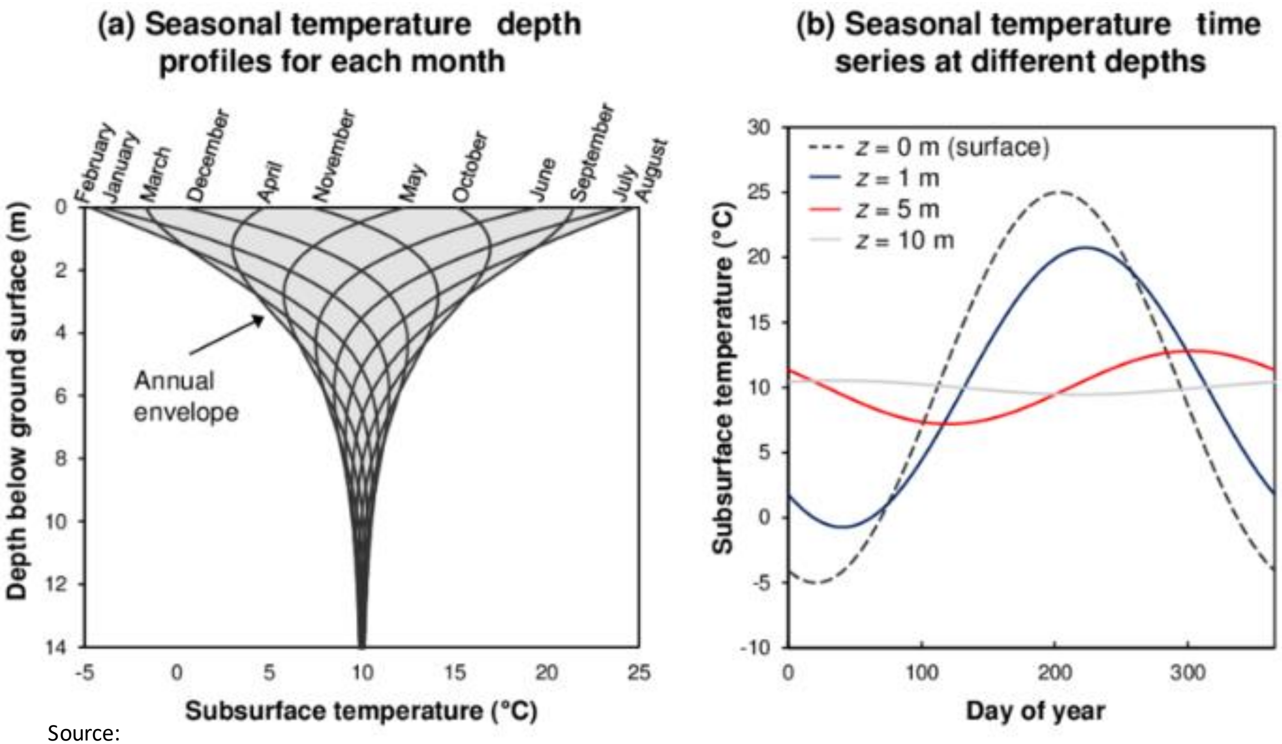
GHP Performance



Source:
https://www.researchgate.net/publication/277210659_Shallow_groundwater_thermal_sensitivity_to_climate_change_and_land_cover_disturbances_Derivation_of_analytical_expressions_and_implications_for_stream_temperature_modeling

Capacity Value

GHPs reduce required peak capacity in summer and winter

Cost of capacity can be derived from annual avoided capacity in AESC manual or cost of new entrants (CONE) ~ $7/kW-month

- Counterfactual 2: Remains summer peaking
- Counterfactual 5: Winter peaking, consistent with policy goals

Table 64. Seasonal capacity prices for all modeled scenarios during the new capacity market structure period (post-FCA 18) (2024 $/kW-year)

Year	FCA #	Summer								Winter							
		CF#1	*CF#2*	*CF#3*	*CF#4*	*CF#5*	*CF#6*	*S#1*	*S#2*	*CF#1*	*CF#2*	*CF#3*	*CF#4*	*CF#5*	*CF#6*	*S#1*	*S#2*
2028	19	$31	$17	$17	$34	$17	$51	$17	$17	$0	$0	$0	$0	$0	$0	$0	$0
2029	20	$34	$17	$34	$51	$34	$68	$34	$34	$0	$0	$0	$0	$0	$0	$0	$0
2030	21	$51	$17	$34	$51	$34	$68	$51	$34	$0	$0	$0	$0	$0	$0	$0	$0
2031	22	$51	$17	$34	$51	$17	$68	$51	$17	$0	$0	$0	$0	$0	$0	$0	$0
2032	23	$68	$34	$68	$68	$51	$85	$85	$34	$0	$0	$0	$0	$0	$0	$0	$0
2033	24	$68	$34	$51	$51	$34	$51	$85	$17	$0	$0	$0	$17	$0	$17	$0	$0
2034	25	$85	$68	$68	$85	$68	$51	$85	$51	$0	$0	$0	$17	$17	$0	$0	$0
2035	26	$68	$68	$17	$34	$34	$34	$85	$17	$0	$0	$17	$51	$68	$51	$0	$51
2036	27	$51	$51	$0	$0	$17	$0	$68	$0	$0	$0	$17	$51	$68	$51	$0	$17
2037	28	$85	$68	$0	$0	$0	$0	$85	$0	$0	$0	$68	$85	$85	$68	$0	$51
2038	29	$85	$85	$0	$0	$0	$17	$85	$0	$0	$0	$51	$85	$85	$85	$0	$34
2039	30	$68	$68	$0	$0	$0	$0	$68	$0	$0	$0	$68	$68	$85	$68	$0	$34
2040	31	$126	$68	$0	$0	$0	$0	$85	$0	$0	$0	$68	$68	$114	$51	$0	$17
2041	32	$85	$68	$0	$0	$0	$0	$85	$0	$0	$0	$68	$51	$102	$68	$0	$34
2042	33	$68	$51	$0	$0	$0	$0	$85	$0	$0	$0	$85	$34	$114	$51	$0	$34
2043	34	$85	$68	$0	$0	$0	$0	$85	$0	$0	$0	$85	$34	$114	$51	$0	$34
2044	35	$85	$51	$0	$0	$0	$0	$85	$0	$0	$17	$85	$34	$114	$34	$17	$17
2045	36	$114	$85	$0	$0	$0	$0	$114	$0	$0	$0	$68	$34	$102	$51	$0	$34
2046	37	$114	$85	$0	$0	$0	$0	$85	$0	$0	$17	$85	$34	$85	$34	$0	$34
2047	38	$126	$85	$0	$0	$0	$0	$85	$0	$17	$17	$68	$34	$68	$34	$0	$17
2048	39	$85	$68	$0	$0	$0	$0	$68	$0	$17	$34	$85	$34	$85	$34	$17	$34
2049	40	$85	$51	$0	$0	$0	$0	$85	$0	$17	$17	$85	$51	$114	$34	$34	$34
2050	41	$68	$51	$0	$0	$0	$0	$68	$0	$17	$17	$68	$34	$85	$34	$17	$17

DRIPE Estimates

AESC 2024 for Maine: Levelized energy DRIPE (11 years) = $6.49 - $39.01 / MWh in system-benefit

Table 106. Seasonal energy DRIPE values for measures installed in 2024 (2024 $ per MWh)

Type	Season	Period	CT	MA	ME	NH	RI	VT
Intrazonal	Summer	On-Peak	$4.63	$9.71	$2.33	$2.57	$1.49	$0.14
		Off-Peak	$2.69	$5.72	$1.49	$1.56	$0.84	$0.09
	Winter	On-Peak	$8.34	$18.03	$5.05	$5.14	$2.62	$0.32
		Off-Peak	$7.15	$15.72	$4.61	$4.51	$2.24	$0.28
Interzonal	Summer	On-Peak	$16.44	$10.87	$18.65	$18.34	$19.45	$20.66
		Off-Peak	$9.82	$6.49	$10.97	$10.86	$11.59	$12.26
	Winter	On-Peak	$31.50	$20.90	$34.65	$34.42	$36.99	$39.01
		Off-Peak	$27.66	$18.30	$30.10	$30.06	$32.37	$34.09

Note: Values shown are levelized over 15 years for Counterfactual #1.

Sum peak and off-peak GHP savings for each season ~ $0.35/kWh

GHP system vs. ccASHP (2,200 kWh/year saved) or ENERGY STAR ASHP (9,800 kWh/year saved)

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Transmission and Distribution

Triennial VI Filings – Appendix E

- Avoided Cost for Pooled Transmission Facilities (PTF): $68.6 / kW-year
- Maine Specific Non-PTF Annualized: $20.81 /kW-year
- Maine Specific Transmission Annualized: $43.31 /kW-year
- Maine Specific Distribution Annualized: $278.18 / kW-year

Total GHP Transmission/Distribution Value = $400/kW (PV) over 25-year system life

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Emissions

Annual emissions reductions from GHP compared to various fuels:

Electric Resistance (tons Co2 avoided)	Cold Climate ASHP (tons Co2 avoided)	Natural Gas (tons Co2 avoided)	Propane (tons Co2 avoided)
3.6	0.6	4.2	6.7

Values for social cost of carbon range widely from $51/ton (IWG), to $200+/ton (EPA 2023)

Emissions reduction value of a 5-ton GHP w/ 25-year lifespan (2.5% discount rate) = $650 - $24,000

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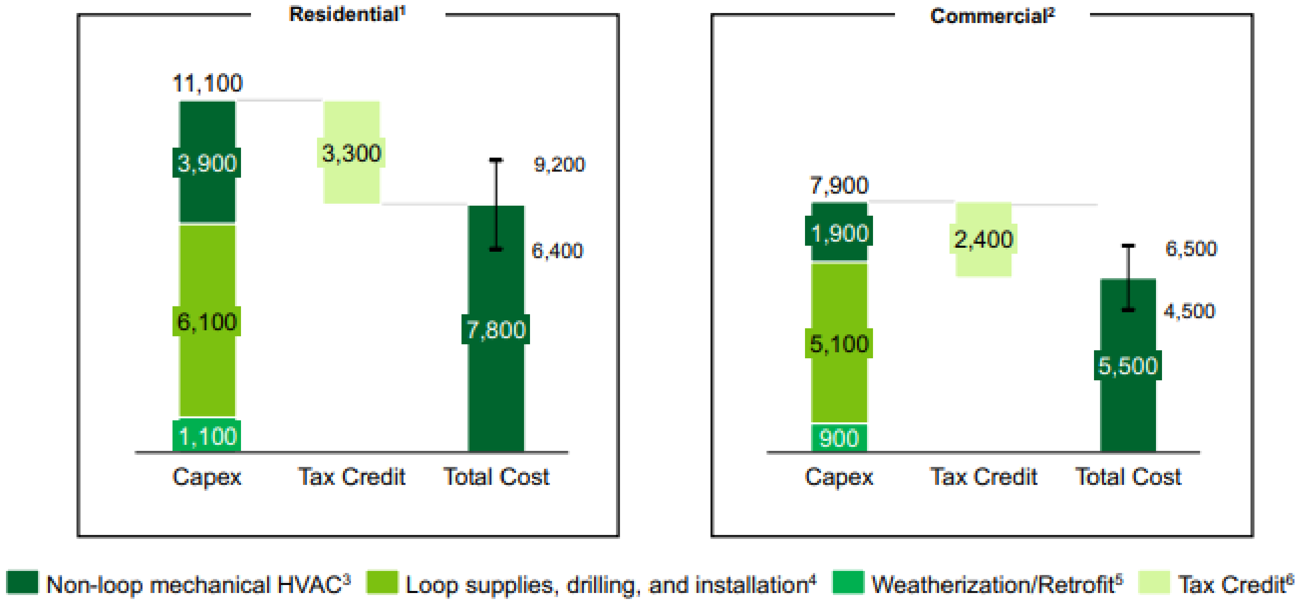
GHP Costs and Savings



ES Figure 5: Median national cost estimates for single-building geothermal heat pumps ($/ton).

Source: *Pathways to Commercial Liftoff: Geothermal Heating and Cooling,* U.S. Department of Energy

- GHPs represent less than 1% of current market
- Significant opportunities for cost reductions via economies of scale
  - Lower heat pump production costs
  - Drilling efficiency / redeployment savings
  - New construction developments

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Alternate Methodology: Total Present Value Cost of Ownership

Simple Cycle Gas Turbine Power Plant

- "Purported" Cost = $1,000 - $1,500 per kW
- "Full Cost Accounting" = $4,300 - $7,400
- Data Centers have caused a large cost increase in gas turbine initial cost
- Data source include EIA, Lazard, Dominion-VA IRP

Summary of Cost Categories Comprising the All-in-Cost of New SCCT Cap

Range	units	Low (P10?)	Mid (P50?)	High (P90?)
Overnight Capital Cost	($/kW)	$1,000	$1,510	$2,158
P-V: All LT Debt Interest Paid	($/kW)	$748	$1,263	$1,958
P-V: All Fixed O&M Costs	($/kW)	$96	$152	$269
P-V: All Fuel Costs	($/kW)	$304	$1,119	$2,592
P-V: All Variable O&M Costs	($/kW)	$40	$114	$185
P-V of Xmission Costs	($/kW)	$124	$163	$228
All-in Cost of an SCCT	**($/kW)**	**$2,312**	**$4,321**	**$7,389**
P-V: REC SCCT Offset Costs	($/kW)	$88	$448	$926
TOTAL CAPACITY COST	**($/Kw)**	**$2,400**	**$4,770**	**$8,315**
PV of Interest During Construction		tbd	tbd	tbd
PV of Reduced Distr Syst Cost ($/kW		tbd	tbd	tbd

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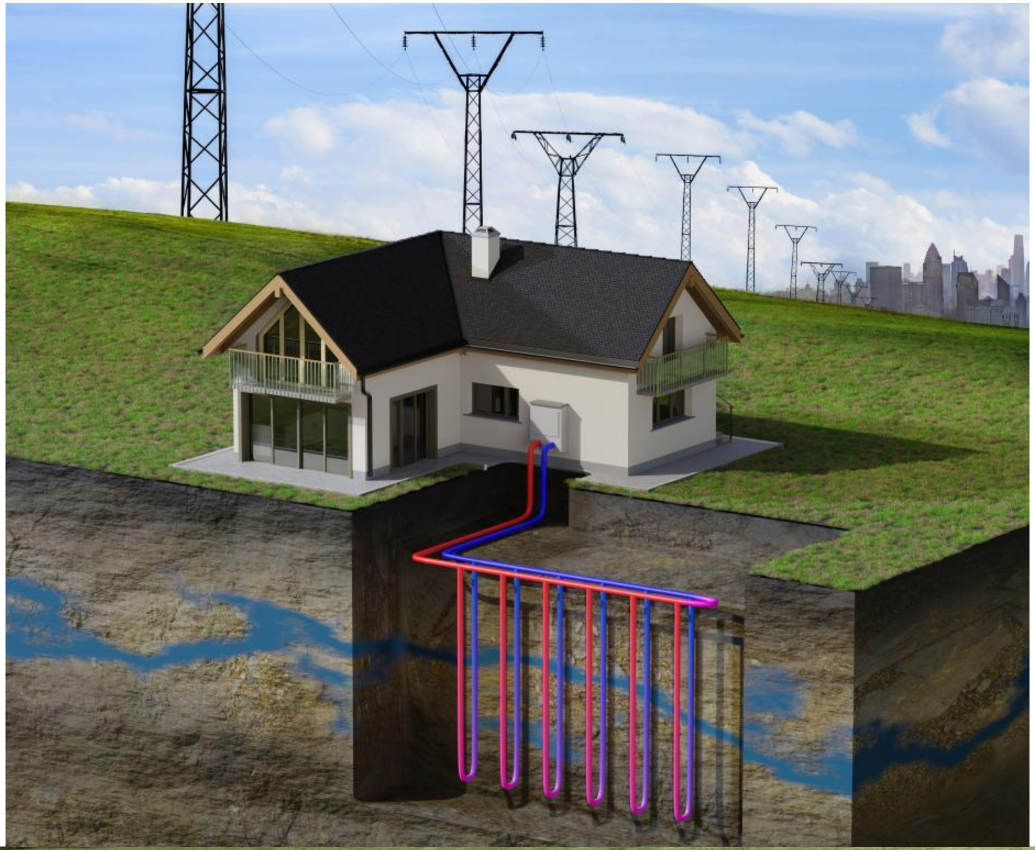
Preliminary study results from draft study for Geo-Exchange (3/25)

2023 DOE/NREL Study:
Grid Cost Reduction via Mass Deployment of GHPs



Links to Study

https://info.ornl.gov/sites/publications/Files/Pub196793.pdf

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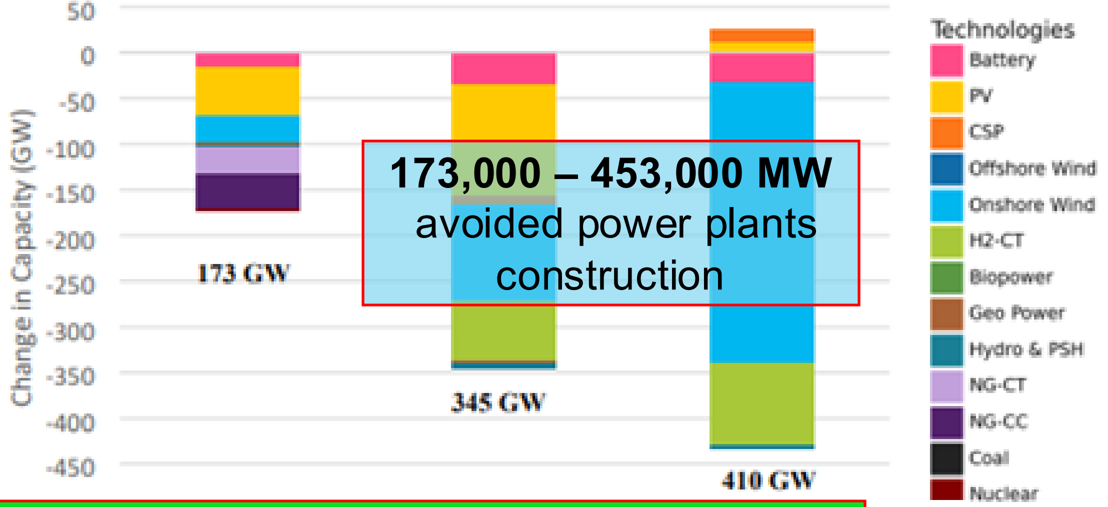
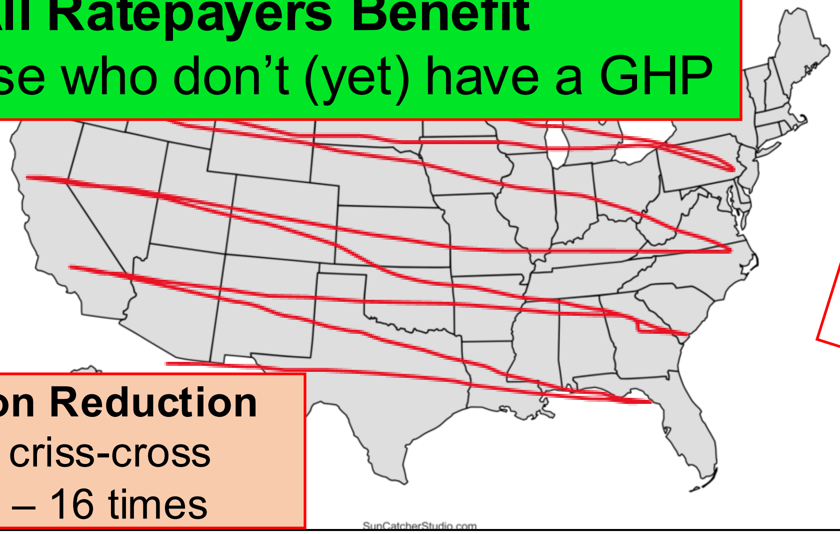
"The Grid" is the Biggest Value Driver for GHPs (i.e. the most important "Customer")

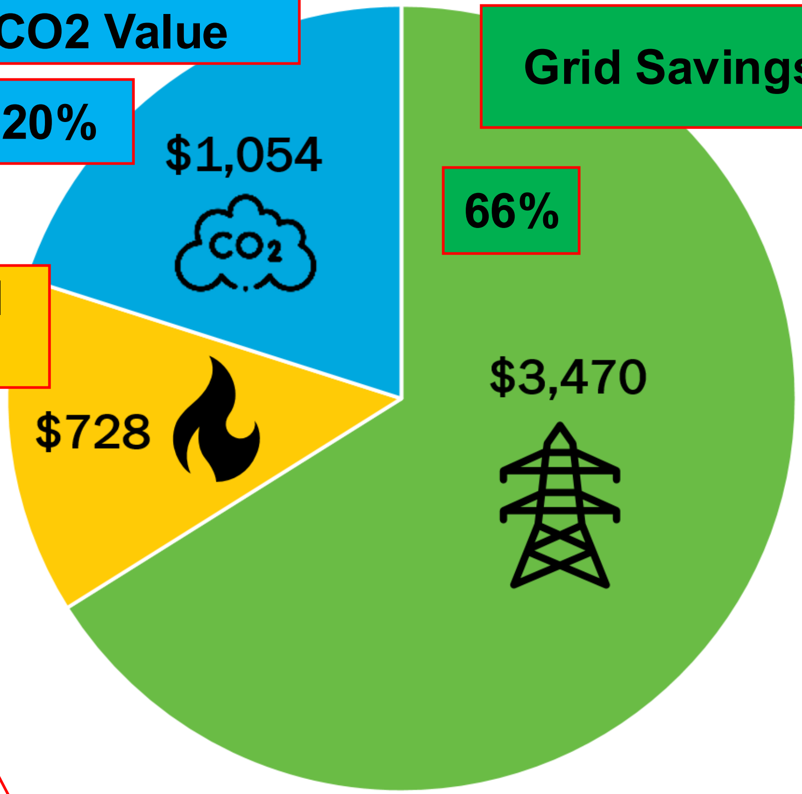


173,000 – 453,000 MW
avoided power plants construction

All Ratepayers Benefit
Even those who don't (yet) have a GHP



Transmission Reduction
enough to criss-cross CONUS 8 – 16 times



Tradeable CO2 Value
20%

Grid Savings
66%

Heating Fuel Savings
14%

We decarbonize for the benefit of future generations, so use their economics

2050 Total Present Value: $5.3 trillion

Data from IGSHPA Townhall Webinar & GHP Impacts Study

KitzWorks Additions/Comments are outlined in red

October 17, 2025

Dan Burgess
Acting Commissioner
Maine Department of Energy Resources
62 State House Station
Agusta, ME 04333

Re: GeoExchange Comments in Response to *Request for Information Regarding Thermal Energy Networks Pursuant to Resolves 2025, ch. 67 (LD 1619).*

Dear Commissioner Burgess:

Thank you for the opportunity to provide information to the Maine Department of Energy Resources (DOER) regarding the deployment of thermal energy networks (TENs) in the state. GeoExchange is a nonprofit trade association promoting the manufacture, design, and installation of GHP heating and cooling technologies. Our members include manufacturers, installers, technology providers, utilities, and others in Maine and across the country.

Geothermal heat pumps (GHPs) – which typically provide the majority of thermal energy for TENs – are one of the most efficient heating and cooling systems available and can significantly reduce greenhouse gas emissions and energy bills for businesses, non-profits, and residents across the state. GHPs use 70% to 80% less energy than conventional heating or cooling systems according to the U.S. Department of Energy,[1] and can reduce emissions by 85-90% compared to conventional fossil fuel HVAC systems.[2]

GeoExchange supports the creation of a Thermal Energy Network program, and offers the following feedback in response to the Request for Information:

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

> GHPs have the potential to significantly reduce peak electric demand compared to other zero-emissions alternatives, allowing them to serve as critical grid assets. The peak reduction capabilities of GHPs will become increasingly important as Maine's electric distribution system

[1] U.S. Department of Energy, "Heat Pump Systems," accessed May 6, 2024, https://www.energy.gov/energysaver/heat-pump-systems
[2] Reeg, Lauren, et. al, "Clean Energy 101: Geothermal Heat Pumps," RMI, March 29, 2023, https://rmi.org/clean-energy-101-geothermal-heat-pumps/

shifts to become winter-peaking, anticipated as soon as 2035.[3] According to calculations performed by GeoExchange leveraging state-level data from the National Renewable Energy Laboratory, a GHP installation can reduce peak demand by upwards of 10 kW per home in the winter compared to cold-climate air source heat pumps, yielding over $40,000 in grid benefits per system.

When designed to support a diverse building load, TENs can be even more efficient than individual GHP installations, producing even greater benefits to Maine's electric grid. GeoExchange encourages the DOER to consider the grid benefits of thermal energy networks to Maine's electric grid as they consider funding mechanisms for future system deployments. I have included the full analysis as an enclosure to this letter.

8) Funding opportunities and cost recovery mechanisms, including, but not limited to: a) Leveraging applicable tax credits and other federal assistance;

The recent tax policy legislation H.R. 1 removed or accelerated the sunset of tax credits for a variety of clean energy technologies, but did not reduce or eliminate the investment tax credit for geothermal heat pump property under section 48 of the internal revenue code. TENs will therefore remain eligible for tax credits of up to 40% (30% base credit and 10% domestic content bonus credit).

H.R. 1 sunset the residential clean energy credit (section 25D) for residential geothermal heat pump owners after December 31, 2025. This may lead TENs system owners to propose retaining ownership of the heat pump equipment inside residents' homes – at least for the duration of any tax credit recapture period. This ownership structure is different than most legacy energy efficiency programs, and the DOER should remain open to these new models as a mechanism to reduce overall system cost.

H.R. 1 also newly authorized leasing of geothermal heat pump equipment as eligible for the section 48 ITC; this change will also open new opportunities for leasing of geothermal heat pump systems for residents outside a TENs footprint, while yielding similar tax credits and financial benefits.

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

---

[3] "Avoided Energy Supply Components in New England: 2024 Report," *Synapse Energy Economics, Inc.* February 7, 2024, https://www.synapse-energy.com/sites/default/files/AESC%202024.pdf, p. 103.

Low-income households and affordable housing particularly benefit from the long-term operational savings of GHPs, significantly reducing energy costs for residents and housing providers. By leveraging a combination of federal and state-level incentives, affordable housing developments have been completed or are underway in states such as Michigan,[4] Colorado,[5] New York,[6] Massachusetts,[7] and Wisconsin,[8] providing long-term energy savings to households that need it most.

10) Additional considerations including: a) Technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks;

TENs provide the highest levels of efficiency when system designers can pair multiple, diverse, offsetting loads in close physical proximity. In more rural areas of the state, TENs may be less advantageous due to longer physical distances, which requires greater up-front investment and more energy to power pumping systems. In these areas, deploying a large number of individual-building GHP systems can often achieve the same emissions and peak-demand reduction benefits at a lower overall system cost. GeoExchange encourages the DOER to also consider pairing widespread deployment of GHP systems along with TENs to optimize overall system benefits across the state.

Thank you for the opportunity to provide feedback to the DOER on this important program.

Sincerely,

Ryan Dougherty
President
Geothermal Exchange Organization

[4] Venclovaite-Pirani, Amanda, “What to know about affordable housing at 121 Catherine St.” The Michigan Daily, February 19, 2024, https://www.michigandaily.com/news/ann-arbor/everything-you-need-to-know-about-affordable-housing-at-121-catherine-st/

[5] “Willoughby Corner, a New 400-Unit Affordable Housing Development in Lafayette ,” Colorado Construction and Design, accessed May 15, 2024, https://ccdmag.com/project-updates/willoughby-corner-lafayette/

[6] Hoffman, Connor, “Housing Authority recognized for geothermal work | Local News,” Lockport Journal, July 22, 2017, https://www.lockportjournal.com/news/local_news/housing-authority-recognized-for-geothermal-work/article_17ea7655-8d2c-5556-b1b8-b56574069e89.html and Galindo, Nadia, “Affordable housing project to use geothermal energy,” News 12 Westchester, November 1, 2023, https://westchester.news12.com/affordable-housing-project-to-use-geothermal-energy

[7] “Healey-Driscoll Administration Awards $27 Million to Decarbonize Affordable Housing Across Massachusetts,” Office of the Governor of Massachusetts, November 21, 2023, https://www.mass.gov/news/healey-driscoll-administration-awards-27-million-to-decarbonize-affordable-housing-across-massachusetts

[8] Phillipps, Samantha, “Prairie Heights: Breaking New Ground in Affordable Housing,” West CAP, May 2, 2023, https://westcap.org/2023/05/prairie-heights-breaking-new-ground-in-affordable-housing/

Enclosure:
As stated

Thermal Energy Networks in Maine

Response to Request for Information

An Overview of the Benefits for a Thermal Energy Network Program in Maine

17 October 2025

Revision P01

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Contents

1 Introduction

Buro Happold appreciates the opportunity to provide information on Maine's Thermal Energy Network initiatives. We support the state's efforts to advance low-emission heating and cooling solutions that align with climate goals and improve energy affordability for all Mainers. This response outlines key considerations for the general feasibility, benefits, and general cost considerations, among other key insights into thermal energy networks (TENs) based on our experience across the United States and Europe.

Buro Happold's Energy team specializes in decarbonization strategy, distributed energy resources, and utility-scale planning. Our experience includes the design of district energy systems (including TENs), development of electrification strategies, and stakeholder engagement supporting clean energy projects for public and private clients.

We hope this RFI response provides useful information and helps guide future development of these important systems in the State of Maine. For the purposes of this RFI we focus on broad overviews and guidance rather than focusing on the fundamentals of these systems. Useful resources have been provided in links to aid in research. Additional research should be completed by the Governor's Energy Office (GEO) and Maine Department of Energy Resources (DOER) for their Summary Report for the Joint Standing Committee on Energy, Utilities, and Technology.

Maine has an unprecedented opportunity to build upon their leadership of electrification for heating and cooling systems and to improve upon programs related to TENs in other states including legislation, technical guidance, pilot programs, and implementation of full-scale systems. The information gleaned from the successes in other states, along with lessons learned, should guide the Summary Report.

Below is a list of useful resources for getting acquainted with the terminology and feasibility of 5th generation district energy systems, including TENs:

- Home Energy Efficiency Team (HEET). 2024. *A Definitional Taxonomy for (Geo)Thermal Energy Networks. https://cdn.prod.website-files.com/649aeb5aaa8188e00cea66bb/671b0629c6bc4b994c041c9c_2024_GRC_Taxonomy_Magavi_Alberto_Varela.pdf*
- Home Energy Efficiency Team (HEET). 2025. *Networked Geothermal System Components*. https://www.gastogeo.wiki/wiki/Main_Page#Networked_geothermal. August 26.
- Buro Happold. 2019. *Geo Micro District Feasibility Study*. https://www.californiageo.org/wp-content/uploads/HEET-BH-GeoMicroDistrict-Final-Report.pdf. GRS Transactions, Vol. 48.
- Buro Happold. 2025. *Optimal Scenarios for Thermal Energy Networks – UTENJA Perspective*. Item 362. https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=68607

2 Applicability & Feasibility in Maine

Various technical, economic, and social factors influence the feasibility for implementing a TEN for a set of buildings. Technical factors include availability of thermal resources, building thermal demands, building typology and occupancy patterns, as well as integration with existing thermal and energy systems. Economic factors closely mirror technical considerations, but also include funding mechanisms, payback periods, and other macro-economic factors. Lastly, the social considerations relate mainly to participation rates but also factors such as environmental justice and cost burden. Successful projects are those that have high technical, economic, and social feasibility.

2.1 Thermal Resources in Maine

TENs can leverage nearly any source of heating or cooling that can be captured and transferred to water. Resources typically used for these systems include geothermal resources through installation of geothermal wells, surface water heat exchange systems in large bodies of water, and other resources including exhaust from refrigeration, wastewater effluent, data centers, and other commercial/industrial waste heat resources.

2.1.1 Geothermal Resources

Geothermal resources are an important factor in determining the feasibility of TENs. However, it is noteworthy that they are not the only factor in feasibility, as TENs can be developed without geothermal resources if other thermal resources are locally available. Geothermal resources in Maine are likely sufficient to install shallow wells (up to 800 feet) that provide seasonal heat production and storage. Today's geothermal heat exchange (GHX) systems (i.e., geothermal wells in series) are scaled and sized on a site-by-site basis to balance heating and cooling loads of buildings with geothermal variables including thermal conductivity and diffusivity of the geologic formation. Although several well configurations can be constructed for the purpose of geothermal heating and cooling, the most common well configurations are the closed U-loop construction. These typically involve the drilling of a borehole, lowering of an HDPE U-tube (with a supply and return line), and backfilling the annular space with thermally enhanced grout. This configuration locally cuts off groundwater flow around the closed-loop well and therefore mostly relies upon thermal conduction with the surrounding geologic formation.

Newer types of well construction include hybrid closed loop systems where a water well is constructed and either a U-loop assembly or direct heat exchanger are installed within the water well to take advantage of groundwater flow across the screened interval. This type of configuration could prove to be beneficial in Maine, where groundwater flow could enhance system performance and lower overall installation cost relative to conventional closed U-loop configurations.

Resources for the feasibility, design, and construction of GHX systems should be reviewed:

- CSA/ANSI/IGSHPA. 2025. *C448 Series: 25, Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings*.
- ANSI/ASHRAE/IES. 2022. *Standard 90.1, Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings*.
- ASHRAE. 2023. *ASHRAE Handbook, HVAC Applications*.

There are limited studies on geothermal resources in Maine. A study by Martzolf includes a range of thermal fluxes from wells around the state within various geologic formations.[1] These thermal fluxes (when converted to thermal

[1] Martzolf, D. 2016. Atalas of Maine: Geothermal Heat Conductivity of the Bedrock of Maine, Atlas of Maine. Vol. 2016: No. 1, Article 7. https://digitalcommons.colby.edu/atlas_docs/vol2016/iss1/7/#:~:text=Article%20Title,science%20minor%20at%20Colby%20College.

conductivities) appear to be consistent with other regional thermal conductivities where successful TENs have been constructed.

2.1.2 Surface Water Thermal Resources

In addition to geothermal resources, TENs can leverage heat exchange systems with low grade thermal fluxes such as large water bodies. Although many Maine water bodies have relatively low seasonal temperatures relative to a TEN's heating needs, these resources have been successfully tapped in northern latitudes due to the large thermal capacity of a large water body. Water bodies typically integrated with TENs include rivers, lakes, and ocean environments.

These systems can use either open or closed loop configurations. Open loop systems are typically used in ocean or large lake environments and where large thermal demands are present, while closed loop systems are used largely in rivers and lakes, but also ocean environments with sufficient depth and clearance from shipping channels or other marine traffic. Closed loop configurations are becoming more common as they are often more efficient and require fewer permits.

Below is a list of large-scale surface water heat exchange projects in northern climates:

- Enwave. 2025. *Empowering One of North America's Fastest-Growing Cities*. https://www.enwave.com/locations/toronto
- Introba. 2025. *Swell's Landing*. https://www.introba.com/work/projects/sewells-landing
- Cornell University. 2025. *Lake Source Cooling*. https://fcs.cornell.edu/departments/energy-sustainability/utilities-production-distribution/district-cooling/cooling-production/lake-source-cooling

2.1.3 Other Thermal Resources

There are diverse thermal resources available from a variety of engineered systems in the built environment. Below is a short list of systems present in Maine that can be integrated with TENs to serve either as a heating, rejection (for cooling), or storage resources.

- Data centers
- Cold storage or food processing facilities
- Plastics manufacturing
- Paper mills
- Waste-to-Energy facilities
- Biomass facilities
- Ice rinks
- Wastewater treatment plants
- Above ground storage tanks

Maine has all the above facilities across the state. Thermal energy has been traditionally viewed as a waste by-product of these operations. However, TENs can utilize thermal waste as a resource for the built environment. Retrofits to these facilities to capture and inject low grade heat sources can be monetized and provide a service to make TENs more efficient and further reduce emissions.

2.2 Urban Density and TEN Feasibility

A fine line exists between the feasibility of distributed versus networked energy systems. One of the first screening criteria for suitability for TENs is population density, with secondary factors including heat density of buildings within a given study area, new build construction, or local availability of thermal resources. While buildings separated by greater distances will likely benefit from distributed energy solutions such as individual ground-source heat pumps, air-source heat pumps, or other HVAC thermal comfort systems, buildings that are located relatively close to each other tend to benefit most from an integrated district system, such as a TEN.

Less than 40% of the Maine population lives in urban areas which are typically optimal for TENs due to their high heat densities, diverse building uses, and generally larger customer bases. When considering the feasibility of TENs, one rule of thumb would be to use the existing natural gas service territories. If natural gas lines were installed within a given area, there is likely an economic case for the installation of a TEN.

2.3 Residential, Commercial, and Industrial Opportunities

Despite Maine being characterized as being predominantly rural, many smaller communities and town centers can be viewed as ideal settings for TENs. In Massachusetts for example, one of the first successful TEN pilots in the United States was built in Framingham, Massachusetts.[2] This pilot project connected single-family homes, apartments, pubic and commercial buildings with a total of 135 customers. Smaller scale systems in mixed-use areas provide diverse energy loads and could prove to be feasible, even in more rural areas.

Many opportunities for TENs also exist for commercial and industrial applications such as office buildings, manufacturing facilities, storage facilities, or other large-scale production where heat is needed.

To determine the load potential for a given area, various resources are typically used to better understand energy consumption from buildings. National datasets are available through the National Renewable Energy Laboratory (NREL) ResStock and ComStock models which are publicly available databases that generalize thermal loads across building typologies. From these datasets, energy use profiles are developed to understand the theoretical load balance for a pilot or full-scale TEN. Diverse load profiles with different heating and cooling demands will result in a more successful TEN, as these networks are designed to share thermal energy.

- National Renewable Energy Laboratory (NREL). *ResStock, Highly Granular Modeling of the U.S. Housing Stock*. https://resstock.nrel.gov/
- National Renewable Energy Laboratory (NREL). *ComStock, Highly Granular Modeling of the U.S. Commercial Building Stock*. https://comstock.nrel.gov/

Some cities in Maine also have benchmarking for large buildings. For example, Portland has an energy benchmarking protocol where building owners report their energy consumption to a portfolio management system. These databases are useful resources to determine locations which are underperforming relative to comparable building typologies and may represent individual or groups of buildings which could benefit from updates, which result in lower overall costs for implementing TENs. In other words, retrofits of buildings can be done with hydronic systems so they can be connected to a TEN as they are updated and the network becomes available.

[2] Eversource. 2025. *Geothermal Pilot in Framingham*. https://www.eversource.com/residential/save-money-energy/clean-energy-options/geothermal-energy/geothermal-pilot-framingham

2.4 Companion Technologies

Due to the nature of converting to a district energy system, incumbent systems may exist within the building. There may also be a need for redundancy or backup systems. The preference for these systems should be electric, however existing systems such as natural gas boilers can also remain if useful life has not expired. The key consideration for leveraging these systems is to use hydronic based distribution to allow integration with the TEN, thereby increasing efficiency and decreasing costs.

2.5 TEN Configurations

A major note of importance is that the system configuration of a TEN can greatly impact efficiency. There are 5th generation district energy systems that use 4, 2 and 1 pipe configurations. Four pipe systems segregate heating and cooling with a supply and return line for both hot and cold water. These are generally not used in modern configurations of TENs due to their inefficiency. Two pipe systems also segregate heating and cooling lines but circulate water in the system within circuits. Single pipe (or ambient temperature loop [ATL]) configurations are now viewed as the optimal system for their simplicity in construction and operation by only utilizing one loop that has fluid circulating within circuits. This system enables diverse heating and cooling loads to share thermal energy across buildings and leverage diverse thermal resources as discussed in Section 2.1. Water is the primary circulating heat transfer fluid in these systems, with anti-freeze (typically food-grade) sometimes added for protection depending on the climate.

3 Pilot & Full-Scale Projects in North America

3.1 Pilot Projects

Pilot programs have been a key driver for TENs in the last decade. These programs have been developed through legislative action and through proactive implementation at many public, commercial, and university campuses nationwide. Below are a list of pilot projects that have been recently implemented in North America:

- New York State Department of Public Service. 2025. *Proceeding on Motion of the Commission to Implement the Requirements of the Utility Thermal Energy Network and Jobs Act Docket 22-M-0429*. https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=68607
- Maryland Energy Administration. 2025. *Maryland Public Service Commission Case No. 9749. https://webpscxb.psc.state.md.us/DMS/case/9749*
- Massachusetts Department of Public Utilities. 2025. *Docket 25-78*. https://eeaonline.eea.state.ma.us/dpu/fileroom/#/dockets/docket/12613

Note that many pilot projects are mandated in several states for the public utilities. This has been successful in some respects, however, there have been challenges in implementing these programs and there have been many lessons learned (see links above). We recommend Maine not only look at utility thermal energy network programs (UTENs), but expand to encompass other campuses, towns and cities as well.

3.2 Full Scale Projects

Many projects have been implemented beyond pilot phase, and in fact many projects are able to proceed to full scale after feasibility studies. This largely depends on the risk and availability of funding (e.g., private financing versus utility owned). Below is a list of resources related to full scale TEN projects in North America.

- Building Decarbonization Coalition (BDC). 2025. *Neighborhood-Scale Building Decarbonization Map*. https://buildingdecarb.org/neighborhood-scale-projects-map
- Colorado Mesa University. 2025. *Geo-Grid System*. https://www.coloradomesa.edu/sustainability/initiatives/geo-grid.html
- Department of Energy (DOE). 2025. *Geothermal Heat Pump Case Study: Epic Systems Corporation*. https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-study-epic-systems-corporation
- Princeton University. 2025. *Path to Net-Zero: Campus Upgrades*. https://facilities.princeton.edu/projects/path-net-zero-campus-upgrades

Note that many of the full-scale projects implemented are through public and private universities, private companies, and public campuses. These projects have been largely hailed as successes with lower energy costs, lower emissions, and higher reliability with owners, operators, and tenants generally expressing pride.

3.3 Ownership Models

There are three primary ownership models that should be evaluated as part of the Summary Report: private, public-private partnership (P3), and 3rd party. All ownership options have proven to be successful for many TENs throughout the United States and there is no one size fits all option. Many factors will dictate which option is best for a given TEN, including capital investment, long term operations and maintenance (O&M), contract terms and guarantees, as well as rate structure. Private ownership allows the owner to maintain flexibility in system modifications and in maintenance, although private contractors are frequently needed for operations due to their expertise with these newer systems. P3s are typical used for large cities or towns and constitute a hybrid option in many respects. They allow local involvement in decision making, especially when residents are involved. Lastly, the 3rd party option allows the private investment and long term buy-back of a TEN. This option is especially attractive when capital is not readily available. This option typically entails instant energy savings and performance guarantees. Typically, the 3rd party ownership model is by an energy as a service (EaaS) company or energy service contractor (ESCO).

Below are several examples for the P3 and 3rd party models. Private ownership is relatively straightforward and can be seen in many of the utility or campus TENs. Note that there is no one size fits all and various hybrid options can also be developed for ownership, governance, and operations.

Public Private Partnerships:

- Troy, New York. 2025. *Troy Local Development Corporation*. https://www.troyny.gov/306/Troy-Local-Development-Corporation
- Saint Paul, Minnesota. 2025. *The Heights Awarded $4.7 Million for Geothermal Energy System*. https://www.stpaul.gov/news/heights-awarded-47-million-geothermal-energy-system

3rd Party:

- Cordia Energy. 2025. *Omaha Reliable Energy at the Core of Downtown Omaha*. https://cordiaenergy.com/locations/omaha/
- Vicinity Energy. 2025. *Boston, For Over 90 Years, the Vicinity Energy District Energy System has Served Reliable, Resilient, and Sustainable Energy to Boston's Leading Businesses.* https://www.vicinityenergy.us/locations/boston/

4 Lifecycle Cost Profiles and Broader Economic Benefits

4.1 Costs and Benefits Compared to Incumbent Technologies

TENs have proven to be more cost effective over their lifecycle when compared to incumbent technologies such as natural gas boilers for heating, electric resistance heating, chillers and/or evaporative coolers, window air-conditioners, and even air-source heat pumps. The benefits of TENs depend on many factors and will vary in degree of effectiveness on a case-by-case basis. The cost profiles generally show that despite higher upfront capital costs from civil infrastructure installation and borefield construction. Despite their higher upfront capital costs, TENs can reduce overall energy consumption, reduce peak electrical consumption and resulting charges, and reduce water consumption. These factors can make them an attractive investment when planning for the future as they can have payback periods of under a decade in some cases. Maintenance of these systems is often less expensive than incumbent or alternative systems such as air-source heat pumps.

It is noteworthy that gas is relatively inexpensive when compared to electricity. The costs of gas consumption extend beyond the building for which they serve and can be volatile and unpredictable. Due to their currently low prices, a business-as-usual scenario may appear less expensive than TENs now, however this may not always be the case. Maine climate goals, legislation, and public recognition generally back the idea that natural gas is not sustainable as a long-term heating source for many reasons, therefore public support, mandates, and utility incentives for electrified heating systems may preclude business-as-usual gas consumption as an alternative for some buildings.

In addition to their relatively short payback period, these systems offer added benefits that extend beyond the building interface. Due to reduced peak electrical consumption, electrical distribution costs can be deferred or even eliminated due to the reduced electrical loads that these systems offer. In comparison to air-source heat pumps, TENs almost always result in lower electrical upgrade costs, as electrical service is often required to accommodate the increased winter peak electrical loads from air-source heat pump installation.

Lastly, TENs have longer lifespans than incumbent systems and air-source heat pumps which generally have lifespans on the order of 15 to 20 years. Alternatively, water source heat pumps connected to TENs have lifespans extending beyond 30 years. In addition, central infrastructure for TENs are typically installed with design lifespan of 50 years, with some sources indicating the lifespan could be up to 100 years. These factors should be considered in a lifecycle cost analysis on a case-by-case basis to demonstrate realistic feasibility of alternatives.

4.2 New Construction Versus Retrofits

It will almost always be less expensive to construct a TEN for new building construction due to the ability to pair construction and in-building installations with water source heat pumps in mind. One way that TENs can be scaled as a technology is through requiring developers to consider these systems to better understand their techno-economic feasibility prior to installing incumbent technologies.

4.3 TENs, Jobs, and Broader Economic Benefits

It is worth mentioning here that TENs hold massive benefits not only to consumers, but also to the public broadly. Not only do they reduce energy costs through reduced production, transmission, and distribution of energy, but they also represent large capital costs and long-term maintenance. This represents an unprecedented opportunity to strengthen Maine's workforce, upskill labor, and provide a pathway for clean energy jobs. TENs require skilled labor for each component of the network, including laying and fusing distribution pipes, constructing pump houses, drilling geothermal wells, installing systems within buildings, and operating and maintaining systems across the network. Many of these jobs exist within the Maine workforce, with an opportunity for development and job creation. For every $1 million spent on these systems, upwards of 5 jobs could be created.

5 Electrical Grid Resilience, Reliability, and Costs

5.1 Peak Load Smoothing

One of the most beneficial aspects of TENs is their ability to lower peak energy consumption. As building systems are electrified in northern climates, they tend to shift peak electrical consumption from the summer (when window air-conditioners spike electrical consumption during heat waves) to winter (when cold snaps increase air-source heat pump or electric resistance heating demand). This shift from summer to winter and increase in overall peak adds stress to the already aging grid and can cause reliability issues if not accommodated by additional grid capacity. With TENs, however, peak electrical consumption tends to decrease in both summer and winter periods due to the use of relatively constant, ambient ground temperatures.

Several pieces of research have proven that "smart" electrification will ease capacity constraints and reduce costs for rate payers:

- Buonocore, J. et al. 2022. *The Falcon Curve: Implications of Seasonal Building Energy Use and Seasonal Energy Storage for Healthy Decarbonization*. https://www.researchsquare.com/article/rs-1054606/v1
- Buro Happold. 2025. *The Role of TENs in the Grid of the Future*. Public Comment # 5. https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=24-e-0165

5.2 Avoided Transmission and Distribution Costs

An analysis completed by Oak Ridge National Laboratory concluded that with the mass adoption of ground-source heat pumps, transmission & distribution (T&D) costs across the country could be reduced by hundreds of billions of dollars by 2050.[3] In addition, they show that even under the business-as-usual grid scenario (without massive increases in demands from electric vehicles and data centers), a savings of $3 per MWh can be realized through mass adoption of ground-source

[3] Oak Ridge National Laboratory (ORNL). 2023. *Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States*. https://info.ornl.gov/sites/publications/Files/Pub196793.pdf

heat pumps. These costs are substantial and generally absorbed by the rate payer. This is of particular importance for Maine, where energy costs continue to rise.

5.3 Reliability and Resilience Improvements

Maine frequently experiences extreme weather conditions. These events may be cold snaps and intense winter storms during the winter, or heat waves in the summer. Both are becoming more common and expected to increase in intensity. Power outages in Maine are also frequent, particularly during the winter, where downed trees can fall due to ice, snow, or wind. A case study in Whisper Valley, Texas is a prime example of how resilient TENs can be during power interruptions.[4] The Whisper Valley TEN lost power during cold snap in 2021, the system was able to maintain its temperature and ramp up home temperatures without spiking electrical consumption. Most importantly, many homes were able to continue heating using their heat pumps with the use of battery backup systems. It is important to design TENs, and any program related to their implementation with backup systems that enhance resilience and reliability.

6 The Role of TENs in Statutory Emissions Targets

Maine has set ambitious climate goals and is a leading state in clean energy solutions. There are further opportunities to improve upon this progress through the implementation of TENs. Buildings represent a large portion of Maine's energy consumption and resulting greenhouse gas emissions and TENs are the most efficient solution on the market.

Some of our models have shown decreases of carbon emissions to $1/10^{th}$ that of business-as-usual scenario (with gas heating and electric cooling). TENs also setup the possible for full decarbonization (net zero) with the connection to a fully renewable grid, making TENs one of the few technologies that could lead Maine to a fully decarbonized future. Although air-source heat pumps are an important technology that can also lead to a decarbonized future, their relatively lower efficiency compared to TENs mean that significantly more renewable energy will be required to accommodate their mass deployment. It will be important to understand Maine's current and future grid emissions factors to better understand what TENs can accomplish in Maine.

7 Closing Thoughts

TENs offer an energy efficient, decarbonized, and energy reduction solution for buildings that extend well beyond building conditioning and comfort. These systems offer economic benefits such as job creation, energy savings for consumers, and societal benefits such as reduced pollution to the environment. Maine has a once-in-a-generation opportunity to effectively and efficiently decarbonize its building stock through implementation of TENs.

[4] Building Decarbonization Coalition (BDC). 2025. *Case Study: Whisper Valley, Texas, A Master Planned Development's Geothermal Network Models Resilience and Scalability.* https://buildingdecarb.org/resource/case-study-whisper-valley-texas

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Comments of the International District Energy Association (IDEA) in Response to Maine Governor's Energy Office/Maine Department of Energy Resources Request for Information Regarding Thermal Energy Networks Pursuant to Resolves 2025, ch. 67

October 17, 2025

Table of Contents

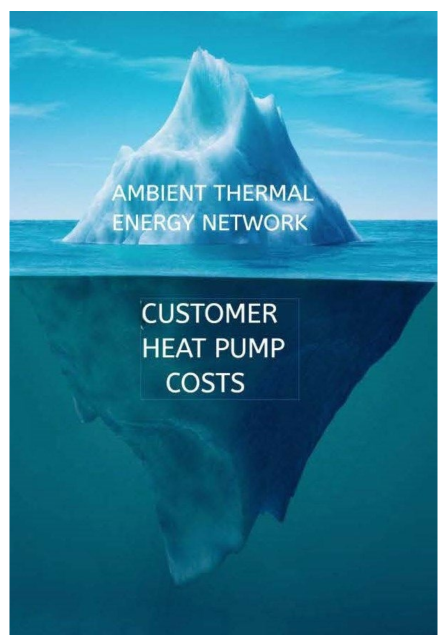
Introduction

The International District Energy Association (IDEA) appreciates the opportunity to provide information in response to the subject RFI.

IDEA was formed in 1909 and today represents about 3,000 members from more than 25 countries around the world. IDEA members own, operate, or provide technology and services to district energy systems that supply steam, hot water, chilled water and energy services to multiple buildings in cities, communities, campuses, airports, military bases, industry and healthcare facilities. Across the globe, district energy systems are recognized for delivering sustainable, efficient and cost-effective energy to their customers while providing enhanced resilience and reliability coupled with environmental benefits for the local economy.

Definition of TENs

The information that the State of Maine receives in response to the RFI may be severely limited by the definition of TEN per the Resolve. Limiting the definition to only systems in which the heat pumps are located in the building (often called ambient loop systems) ignores the many ways that thermal networks can be designed to access and deliver thermal energy to reduce GHG emissions, increase resiliency and mitigate power grid constraints.



Although there is a well-organized advocacy effort which embraces ambient loops as the best way to implement thermal networks, the reality is that the technical and economic track record of these systems is very limited. More will be learned as pilot projects are developed. Some of the ambient loop pilot projects which have been proposed are extremely expensive.

A key reason that ambient systems can be expensive is that, in addition to the costs associated with the thermal production source and the distribution piping, these systems require that heat pump systems be constructed, operated and maintained in the building. These in-building costs are significant and must be considered for a full economic analysis of ambient systems. This is illustrated conceptually in the above figure.

An expansive definition of TENs will maximize the societal benefits of these systems. A better definition would be "systems that distribute thermal energy (heating and/or cooling) to buildings via a network of pipes from one or more sources on the network." This definition describes District Energy Systems (DES), and such systems have a very long track record of delivering economically attractive, low-emissions thermal energy to customers.

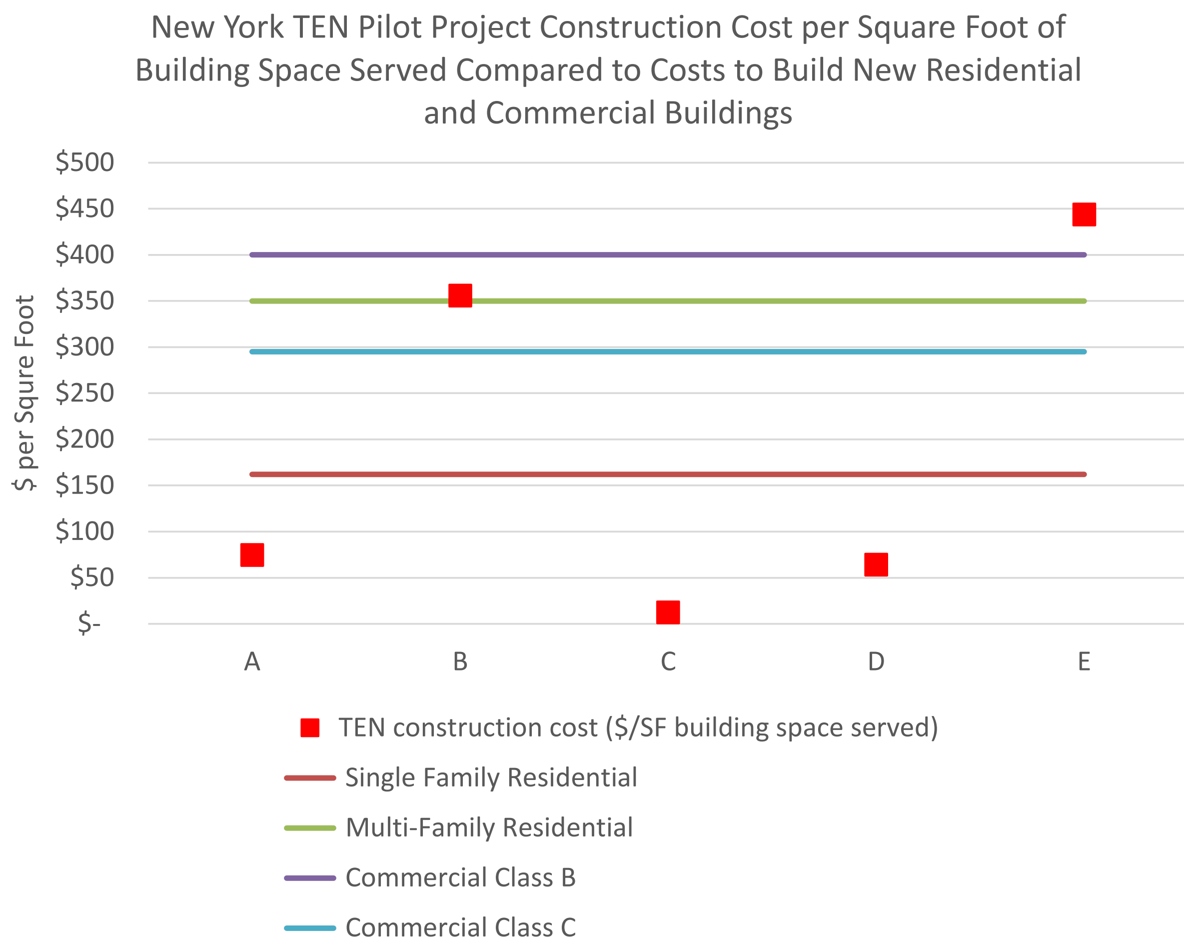
Proposed Pilot Projects in New York

Six TEN Pilot Projects have advanced in the New York TEN Pilot Project design and evaluation process. Construction costs range from $52.4 to 191.7 million, with building area served ranging from 316,384 to 6,690,500 square feet. The design document for project F had no square feet data.

To put the construction costs into perspective, the construction costs per square foot of building space served was calculated, as shown in the table below.

	System Type and Thermal Source	Construction costs ($M)	Square feet of building space served	TEN construction cost ($/SF building space served)
A	2-pipe Ambient Loop, Treated Sewage Effluent	$ 126.4	1,695,136	$ 75
B	2-pipe Ambient loop with geoexchange, refrigeration waste heat, sewer heat recovery and cooling tower.	$ 112.6	316,384	$ 356
C	2-pipe Ambient Loop fed from chiller waste heat, for heat only	$ 83.8	6,690,500	$ 13
D	2-pipe Ambient Loop fed from chiller waste heat	$ 52.4	815,000	$ 64
E	2-pipe Ambient Loop with geoexchange	$ 191.7	432,170	$ 444
F	Two single pipe ambient loops using sewage thermal recovery	$ 118.1	N/A	N/A

In the graph below these costs were compared to the average cost to build various kinds of building space. It is clear that projects B and E have untenable costs – higher than the total cost of constructing building space.



Successful TENs

TENs cannot be cost-effective everywhere. The keys to cost-effective TENs/DES include:

1. High thermal load density, which reduces capital and operating costs per unit of energy.
2. High load diversity, which reduces capital costs because the peak demand for the system is lower than the sum of the individual peak demands. In addition, high load diversity reduces energy costs by facilitating energy sharing between buildings.
3. Good site access to low/no carbon energy sources, which reduces capital costs.
4. Right-sized high-capex capacity. See discussion below under "Balancing Decarbonization and Affordability."
5. Service to new construction, which is significantly more cost-effective than service to existing buildings because buildings can avoid the capital, operation and maintenance

costs of a "business as usual" thermal energy system. This benefit is more problematic with ambient loop systems as noted above.

6. Rapid growth of the system, which allows growth of revenue to better keep pace with capital investments. A related issue is "development risk" – the risk that construction of new buildings (or major renovation of existing buildings) is not achieved or occurs later than projected, thus prolonging the time that revenues are lower than projected for the fully developed system.
7. Incorporation of Thermal Energy Storage (TES) to reduce peak electricity demand and optimize heat pump output. Reduction in peak demand has economic value in many power grids today, and it is expected that this value will increase and become more widespread as power demands grow and grids decarbonize. TES cannot be effectively implemented in ambient systems.

Balancing Decarbonization and Affordability

Energy affordability is a critical concern. While natural gas prices remain relatively low, electricity prices are surging. U.S. residential electricity rates in September 2025 were 6.6% higher than the year before. Achievement of Maine's GHG reduction goals will be much more difficult given the Trump administration's opposition to renewable energy and the rapidly accelerating need for power infrastructure. Natural gas combined cycle plants are the technology of choice for most utilities and technology companies.

The difficult challenge will be balancing decarbonization with the goal of affordability. TENs pilot projects will provide useful information regarding the costs and power demand benefits of different types of TENs. As discussed below, SCIRP can help maximize decarbonization in the most cost-effective manner.

To maximize cost-effective GHG reductions via TENs, policymakers must avoid making the perfect become the enemy of the good. TENs are like people: They must first be born before they can grow into adults. The economic challenges of birth are considerable.

Defining TENs to require "100% purity" (i.e. zero reliance on fossil fuels) will severely and negatively impact the economics and result in far fewer systems actually being born. It is important to allow prospective TENs to "right-size" high capital expenditure capacity such as geothermal heat pumps. Such capacity is more costly than conventional technologies such as natural gas boilers and electric chillers.

Substantial capital savings can be achieved if conventional technologies are used to provide peaking and backup capacity for a TEN. In such hybrid systems the vast majority (typically over 80%) of annual thermal energy can be from heat pumps even if they provide only 40-50% of the total capacity. Systems implemented initially as hybrid systems have a huge advantage in growing up to be financially viable TENs supplying affordable energy.

As these systems grow, they can evolve toward 100% electrification as equipment ages out and technologies advance. Historically, district energy systems have effectively accelerated the transition to lower-carbon technologies because of the flexibility provided by aggregated thermal scale. This has been demonstrated over many decades in Europe and more recently in North America.

The TENs regulatory framework must carefully consider how to maximize decarbonization while honoring the goal of affordability. Twice as much decarbonization will be achieved with 100 systems providing 80% decarbonization than with 40 systems providing 100% decarbonization.

Benefits of TENs

TENs, defined appropriately, can provide enormous benefits relative to energy infrastructure and GHG emissions. Compared with alternative approaches to decarbonization via electrification, TENs can reduce requirements for investment in electricity generation, transmission and distribution infrastructure as well as reduce annual requirements for electric energy. This will save utility ratepayers substantial sums.

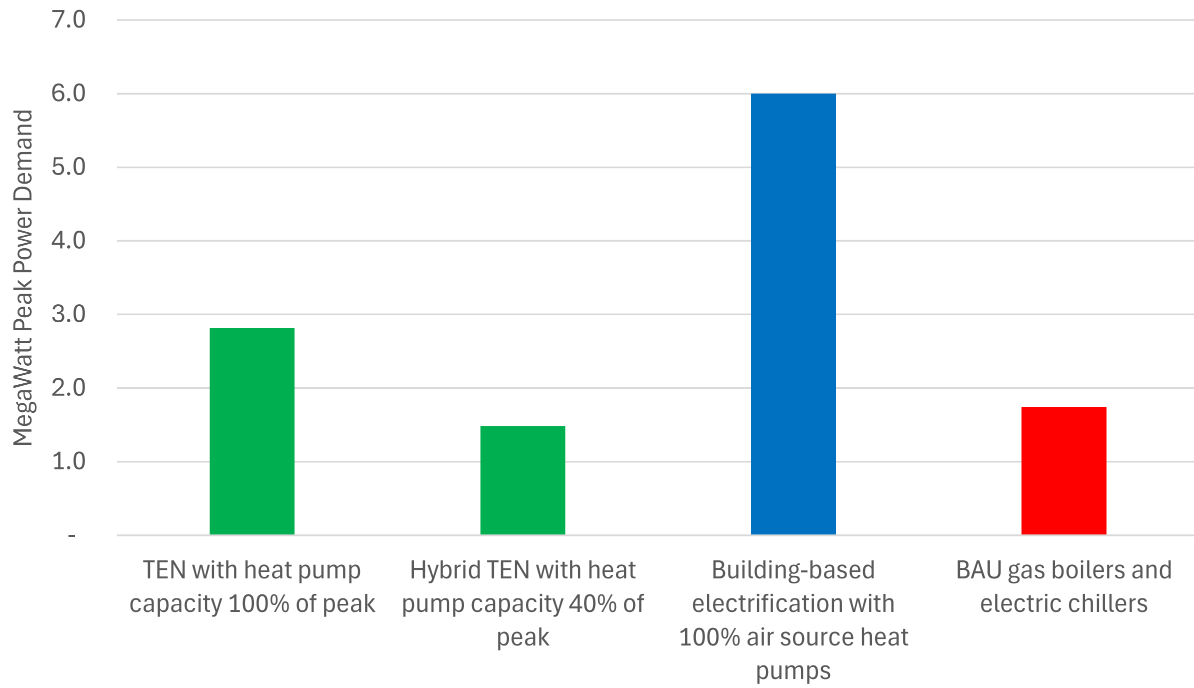
Relative to peak power demand and GHG emissions, how do TENs compare with building-based decarbonization strategies, and how do hybrid TENs compare with 100% heat pump systems?

In the following illustrative calculations, I compare four scenarios for a case study for service to a mixed-use collection of new buildings totaling 2.2 million square feet of area:

1. TEN with 100% of peak capacity from geothermal heat pumps;
2. TEN with 40% of peak capacity from geothermal heat pumps, with the remainder provided by natural gas boilers for heating and centrifugal electric chillers for cooling;
3. Building-based decarbonization with 100% of peak capacity from air source heat pumps; and
4. "Business as Usual" (BAU) scenario, using natural gas boilers for heating and electric chillers for cooling.

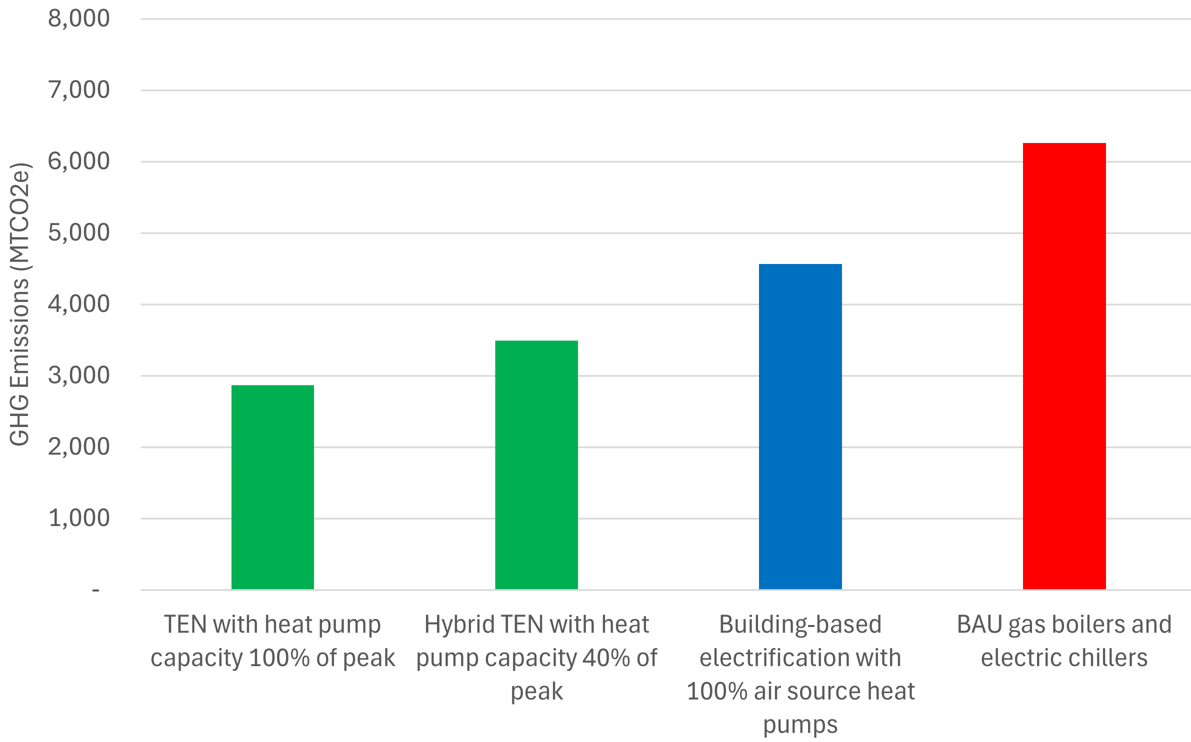
As illustrated in Figure 1, peak power demand for the hybrid TEN is 40% lower than for the 100% heat pump TEN. Compared with the building-based decarbonization strategy, the hybrid TEN reduces peak power demand by 77%. Power demand for the BAU is roughly the same as for the 100% heat pump TEN (due to chiller load).

Figure 1



We have assumed that the marginal electricity resources for this new load are provided by natural gas combined cycle plants. As illustrated in Figure 2, hybrid TEN emissions are 30% higher than for the 100% heat pump TEN. However, as discussed above, the hybrid TEN has a much better chance of actually getting built. Compared with the building-based decarbonization strategy, the hybrid TEN reduces emissions by 47%. Compared with the "Business as Usual" scenario, the hybrid TEN reduces emissions by 75%.

Figure 2



Clearly, TENs can provide enormous benefits relative to energy infrastructure and GHG emissions. Hybrid TENs can supply most of those benefits at a much lower cost than systems with heat pumps providing 100% of initial capacity.

Implementing Pilot Projects

Pilot projects should be solicited to demonstrate a range of thermal network designs (not just ambient loops) and thermal sources. Further, in addition to technical variables, pilots should also demonstrate alternative business models, may include but not be limited to natural gas utility ownership, outsourcing to private thermal utility companies, municipal ownership or cooperative. Pilots should track "shadow rates" to quantify what thermal service rates would be if all costs were recovered from the customers served by the TEN. Although lower rates would need to be charged to induce customers to participate in the pilot, the rates charged should be meaningful but generally designed to offer a discount to current customer costs.

Encouraging Competition Post-Pilot

It is important that post-pilot development of TENs be procured on a competitive basis that is open not only to regulated utilities but also other entities such as district energy companies. These companies offer a wealth of development experience, engineering know-how, financial capability, marketing skills and management expertise that can be of immense value in the development of TENs. Most DES have been successfully created, operated and expanded based on long-term thermal service contracts with customers rather than through rate-regulated tariffs.

Sector-Coupled Integrated Resource Planning (SCIRP)

It is critically important to plan energy infrastructure through a SCIRP process that considers natural gas, electric and thermal infrastructure costs holistically.

SCIRP would be triggered when and where the natural gas utility is proposing significant infrastructure repair, replacement or expansion. For the affected service area, the process would address:

- The cost-effectiveness of alternative strategies for electrifying buildings,
- The economics of TENs options to meet thermal requirements,
- Natural gas utility system repair/replacement/expansion costs, and
- Impacts of alternative strategies for electrifying building thermal energy supply on power utility generation, transmission and distribution costs.

If the SCIRP process determines that a TEN results in the lowest societal life-cycle costs, the PUC should procure a detailed feasibility study through a competitive RFQ/RFP process. The study would include recommendations regarding: the appropriate role, if any, of financing based in whole or in part on revenues generated via rate of return on the gas utility rate base; and the appropriate commercial basis (bilateral contracts vs. monopoly) in view of the historical gas utility obligation to serve.

For each recommended TEN, the PUC should solicit proposals for its design, construction, financing, ownership and operation/maintenance. The RFP should go out to potential TEN developers including the local gas utility, the local government, and non-utility private developers/operators of thermal networks. The RFP should be designed to facilitate public-private partnerships and encourage collaboration between utilities, private developers and municipalities.

Cost Recovery for TEN Value to Power Grid

In the SCIRP process the TEN Value to Power Grid (TVPG) would be determined by calculating the economic value to the electric utility of the reduction in electricity demand

and energy of the most cost-effective TENs option compared to most cost-effective building-based electrification option. The TVPG would have two components:

- A capital portion representing the avoided capital investment in electricity generation, transmission and distribution infrastructure made possible by the TEN; and
- An operating portion representing the projected life-cycle energy, operation and maintenance costs avoided by the electric utility made possible by the TEN, discounted by the utility's regulated rate of return.

The TVPG determined in the SCIRP process for a particular TEN would be paid by the electric utility to whatever entity is selected to develop the TEN. Those costs would become part of the utility's rate base.

Cost Recovery for Rate-Base Supported TENs

To encourage uptake of service from TENs, the life-cycle cost of service to the TENs customer should be no higher than costs with current customer systems (or, for new buildings, a default system by building type as established by the PUC), accounting for life-cycle capital, energy, operation and maintenance costs. However, the balance of the gas utility rate base would cover additional costs, if any, associated with decarbonization, after taking into account the TVPG provided from the electric utility.

For TENs systems partly financed by revenues generated from a regulated gas utility rate base, the portion of the financing supported by the rate base would be paid back to the gas utility as the TENs system grows and reaches specified financial benchmarks. The gas would be compensated per its regulated rate of return, with non-participant ratepayers receiving credit including interest.

Inflation Reduction Act Investment Tax Credits

On the federal level, it is important to note the final outcome of the legislation and regulations relating to the Investment Tax Credits in the Inflation Reduction Act (IRA). Passed in 2022, the IRA provides investment and production incentives for clean energy technologies. Since enactment of the IRA, these incentives have been clarified through rulemaking. Further, on July 4, 2025, budget reconciliation legislation was enacted that repealed or amended certain IRA provisions.

Of particular relevance to the district energy industry are incentives for Geothermal Heat Pumps (GHP) and Thermal Energy Storage (TES).

Credit Amounts Generally

The base ITC rate is 6%. The total ITC amount varies depending on the extent to which the project meets certain requirements, as follows:

- If the project meets the Prevailing Wage and Apprenticeship requirements, the credit amount is multiplied by 5.
- Credit is increased by up to 10 percentage points for projects meeting certain domestic content requirements for steel, iron, and manufactured products.
- Credit is increased by up to 10 percentage points if located in an "energy community" (communities that are disadvantaged relative to income or due to the transition away from coal).

Incentives are extensively limited for taxpayers that are specified "foreign entities" or "foreign-influenced entities."

GHP

Definition of Eligible Property

The IRA provides incentives for "equipment which uses the ground or ground water as a thermal energy source to heat a structure or as a thermal energy sink to cool a structure." In the implementing regulations this is also referred to as "geothermal heat pump equipment." The implementing regulations clarify that, in addition to ground or ground water, other working fluids (e.g., glycol) are included as a thermal energy source.

In addition to the costs of borefields (or wells) and heat pumps, costs for thermal distribution from a central plant to buildings are also eligible. Further, although the implementing regulations do not specify energy distribution equipment and components of a building's heating and/or cooling system as components of GHP property, the costs of such equipment that is integral to the function of the GHP property to heat or cool a structure is eligible.

Costs for thermal distribution and building systems are subject to the Dual Use rule, which requires that:

- GHP must supply at least 50% of the annual thermal energy, and
- If so, the incentive for piping and building equipment is equal to the total cost multiplied by the percentage of annual energy supplied by GHP (or other eligible sources).

Phase-out

Through 2032 the base rate is 6%. In 2033 the base rate drops to 5.2% and the increased rate (if the prevailing wage requirements are met) to 26%, while in 2034 they decline to 4.4% and 22% respectively, and go to zero in 2035.

Ownership of Property

The entire unit of GHP property must be owned by one taxpayer or non-taxpayer entity. If geoexchange heat pumps are located in a central plant, the costs of that equipment is eligible for the incentive. With an ambient geoexchange system in which heat pumps are located in buildings and are owned by the individual building owners, the costs of the heat pumps are not eligible for the incentive. However, the owner of an ambient loop system including a GHP borefield is eligible for an incentive for the costs of the borefield and ambient loop as long as that entity also owns at least one heat pump connected to the system and that the Dual Use Rule is met. If the individual buildings (and heat pumps installed in them) are owned by the same entity as owns the GHP system incorporating an ambient loop (e.g., a university), the costs of all equipment is eligible for the incentive.

TES

Definition of Eligible Property

TES property is "property comprising a system that is directly connected to a heating, ventilation, or air conditioning (HVAC) system; removes heat from, or adds heat to, a storage medium for subsequent use; and provides energy for the heating or cooling of the interior of a residential or commercial building."

Phase-out

TES projects have until the end of 2033 to start construction to qualify for credits at the full rate. Such projects that start construction in 2034 will qualify for tax credits at 75% of the full rate and in 2035 at 50% of the full rate. The credit is totally phased out after 2035.

October 17, 2025

To: Maine Governor's Energy Office/Maine Department of Energy Resources

From: David Voss, Energy Transition Consultant, CLEAResult Energetics

Date: October 17, 2025

Re: Request for Information Regarding Thermal Energy Networks Pursuant to Resolves 2025, ch. 67 (LD 1619)

Contact Information:

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CLEAResult is the largest provider of energy efficiency, energy transition, and energy sustainability services in North America. Since 2003, our mission has been to change the way people use energy. Today, our experts lead the transition to a sustainable, equitable, and carbon-neutral future for our communities and the planet. Our world-class technology and personalized services make energy use and greenhouse gas emissions reduction easy for businesses, governments, utilities, and residential customers. Headquartered in Austin, Texas, CLEAResult has over 2,900 employees across the U.S. and Canada and is majority owned by a leading U.S. middle market private equity firm Kohlberg & Company.

CLEAResult's Energy Sustainability Consulting division, Energetics, is a 120-person clean energy consultancy based in Columbia, MD. Energetics was founded to help public- and private-sector clients to understand, evaluate, and integrate clean energy technologies, sustainability measures, and climate and resilience strategies into their real-world operations. Since 1979, Energetics have worked with leaders and innovators in government, industry, and communities to inform and facilitate stakeholders, implement change, and provide certainty where it is most needed. Our staff are personally invested in our mission to deliver solutions for a safe, secure, and sustainable future.

CLEAResult appreciates the opportunity to provide input regarding Maine's Thermal Energy Networks program and to engage with the Maine Governor's Energy Office and Department of Energy Resources on this important topic. We are very interested in supporting GEO and DOER as a strategic technical and analytical advisor, program administrator, and/or implementation partner. Should GEO and/or DOER issue a public Request for Proposals (RFP), CLEAResult would welcome the opportunity to submit a competitive proposal detailing our capabilities, experience, and pricing for providing technical expertise and administering the Thermal Energy Networks program.

We respectfully ask that GEO and DOER keep CLEAResult in mind for any forthcoming RFPs related to this topic. Regardless of the direction the State chooses to pursue, we hope the insights and recommendations provided below contribute to the development of a successful and impactful program. The following section outlines relevant experience and considerations we believe are pertinent to this opportunity.

Feedback Topics

The purpose of this RFI is to solicit information regarding the potential creation of a "thermal energy networks program" for Maine (including, but not limited to, relevant frameworks and pilots, information about costs, feasibility and applicability, recommended processes, life-cycle analyses, electric grid impacts, relevance to Maine's statutory emissions reductions goals, labor considerations, and impact on affordability of housing development and energy), pursuant to Resolves 2025, chapter 67, Resolve, to Direct the Governor's Energy Office to Solicit Information Regarding the Creation of a Thermal Energy Networks Program in Maine (LD 1619 or the Resolve), which was signed into law by Governor Janet Mills on June 11, 2025.

1. *Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;*

Geothermal and thermal energy network (TEN) projects tend to be most financially viable in either very dense urban areas—where energy demand is high and infrastructure can be centralized—or in very rural areas, where land availability and community-scale systems offer cost advantages. In contrast, suburban areas are often better suited for individual HVAC system installations due to their dispersed building patterns. Generally, it's more cost-effective to integrate these systems into new construction rather than retrofit existing buildings. To maximize impact, funding strategies should be aligned with local development costs and project types.

Currently, CLEAResult supports the Geothermal Energy Grant Program (GEGP) and Geothermal Energy Tax Credit Offering (GETCO) for the State of Colorado in collaboration with the Colorado Energy Office. These state incentives support investment in ground source heat pumps, TEN projects and geothermal electricity generation projects. To date, over 60 pilot projects have been funded with over $10M in grant funding and over $13M in tax credit investment, substantially mobilizing the geothermal energy market in the State of Colorado. CLEAResult helped design the application and evaluation process for the State with program materials found here for GEGP and here for GETCO. We are tracking metrics for these projects related to cost savings and efficiencies but as many TEN projects are still in design phase, these metrics are not yet conclusive. The State manages a program performance database for all projects that include qualitative and quantitative metrics including natural gas usage reduction, electricity cost savings, GHG reduction amount, project site characteristics and more.

2. *The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:*

~~a. Geophysical considerations;~~

b. Compatibility with incumbent air source heat pumps and other heating, ventilating and air-conditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network;

Please refer to our responses for other questions, particularly under 10.a and 10.d.

c. Permitting and right-of-way considerations;

TEN infrastructure, primarily the distribution pipeline, are typically buried or otherwise placed below surface and often located next to other kinds of infrastructure such as sewer system, telecommunications cables, and others. Additionally, due to the large scale but limited number of TENs developed, any maintenance and system upgrades or changes are complex undertakings requiring extensive coordination and prolonged permitting processes, which introduce uncertainty and risk for developers, contractors, operators, and/or owners. Some of these risks can be mitigated in part through expedited and/or prescriptive permitting for select portions of the system to offer upfront clarity. These enable all parties involved to better understand potential challenges before beginning design and construction, reducing the likelihood of cascading delays and cost overruns from last-minute changes.

d. Constraints around geographic density; and

TEN systems must be incorporated early in the site design process to allocate room for pipelines. Once roads, foundations, and utilities are in place, adding TEN infrastructure becomes logistically challenging or impossible without major redesign, which is especially the case in dense urban settings. Despite these challenges, TENs are most suitable for larger developments in densely developed areas such as multifamily residential buildings, corporate campuses, and commercial districts, particularly those with mixed uses and shared amenities in urban cores. These facilities typically offer greater load diversity, which helps reduce the required TEN system size and cost while minimizing the risk of thermal drift caused by imbalanced heating and cooling loads. Additionally, shared infrastructure and walls within buildings result in lower per-occupant energy loads, and centralization can lead to more cost-effective solutions than installing individual HVAC systems in each building unit.

Multifamily residential, such as townhomes, can be viable candidates for TEN systems due to their proximity, which reduces the need for extensive piping. However, because these buildings often have less load diversity, careful system sizing is essential to avoid long-term thermal imbalance. In such cases, hybrid systems that incorporate air source heat pumps (ASHPs) or auxiliary components borehole/ground thermal energy storage, like dry coolers or boilers, can help maintain system temperatures and efficiency over time. On the other hand, single-family detached homes can be—although generally less—suitable for TEN deployment as well, particularly for new build neighborhoods. These homes tend to have higher individual heating and cooling loads, lack shared infrastructure, and are spaced farther apart—factors that increase installation complexity and cost. However, there are instances where TENs can be cost effective in new buildings (vs. retrofits) and when done at many single-family homes at once that are co-located within the same community.

Additionally, TENs are highly applicable and beneficial to industrial facilities, particularly in food and beverage manufacturing. These facilities require substantial volumes of steam, hot water, hot air, and other thermal media across a wide temperature range (e.g., 69°F–536°F) to support numerous unit operations such as blanching, drying, pasteurization/retort/sterilization, rendering, vacuum sealing, and washing. TEN-supplied steam is especially valuable for operations that rely on legacy steam-using equipment, which often lack techno-economically viable all-electric alternatives or other novel solutions. In these cases, steam from TENs can be used directly (e.g., peeling fruits or vegetables) or indirectly to heat air or water that then gets used for other processes (e.g., evaporation, boiling, fermentation). Furthermore, industrial facilities enhance TEN system performance by consuming excess heat, helping to balance thermal demand and supply. However, a key constraint is that food and beverage manufacturing sites are frequently located in rural, sparsely populated areas. While land availability may offer cost advantages, the need for extended pipeline infrastructure can diminish the overall value proposition of TEN deployment in these regions.

e. *Other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks;*

More building types add thermal diversity. Homes have different sun exposure/shade, and each home represents different occupant behavior with varying timing and load demand intensity. The cost per building drops substantially due to economies of scale in excavating distribution infrastructure, installing pipelines, and mobilizing equipment. A centralized or community system can also use a common distribution pipeline. This can be maintained by an HOA (in case of homes), utility, or energy service company, reducing the maintenance burden on individual building owners, ensuring regular monitoring, optimized operation, and better data for performance verification. These larger projects may also qualify for larger-scale financing, bulk equipment discounts, and utility or federal funding that single-building projects may not. During Maine's shoulder seasons, diurnal switching between heating and cooling can also take advantage of the efficiency and inherent thermal mass of a TEN.

3. *Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;*

Grant funding for technical assistance to support the evaluation of feasibility for TEN pilots at specific locations is a valuable program element that GEO/DOER should strongly consider. The barrier to entry for TENs is high due to the amount of resources required, including additional permitting, construction logistics, environmental assessments, geotechnical surveys, etc. These additional requirements render TENs less favorable to developers and owners. Providing technical assistance will enhance the feasibility of TENs, generally reduce project risk, encourage investment in the state, improve bankability of larger projects, and create a channel for GEO/DOER to receive feedback and learn from the field continuously. Furthermore, rate structures that valorize the benefits of TENs—such as load smoothing and energy mix diversity/flexibility—could make it more attractive to both developers and building owners. Synergistic programs that build on one another to deliver compounded benefits would further support advancements in TENs.

Additionally, the State of Colorado contracted our services to advise on the application material requirements for their Geothermal Energy Grant Program and Geothermal Energy Tax Credit Offering, for which we developed specific criteria to evaluate projects including feasibility studies and engineering designs. Our team reviewed the technoeconomic feasibility of each application in a detailed review process by our geothermal energy experts aligned with this criterion. We continue to support the State of Colorado to provide technical assistance with managing project implementation by reviewing deliverables and final reports and conducting audits as necessary to ensure that project installations are progressing as anticipated. This has resulted in risk mitigation for the State as we project a level of quality assurance for projects and ensure that taxpayer dollars are going toward successful projects. From our implementation of these and other similar programs in Colorado, we learned that some geothermal heat pump OEMs—among other TEN-compatible systems—provide real-time data monitoring on some of their systems and have offered to provide anonymized data to government entities. GEO/DOER should explore this kind of opportunity to gather real data to compare with program assumptions. GEO/DOER could also provide a higher score for systems that utilize remote data collection.

4. *Life-cycle costs and benefits of commercially available or emerging thermal energy network technologies, including comparisons to incumbent heating and cooling technologies appropriate for the Maine climate;*

When TENs with GSHPs are compared to ASHPS, there are two main advantages: TENs are unaffected by swings in ambient temperatures, while ASHPs lose both capacity and efficiency at temperature extremes. Also TENs do not have issues with fouling and corrosion since they are not exposed to external contaminants like ASHPs.

5. *Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;*

District systems like TENs offer enhanced efficiency and resilience by utilizing diverse energy sources such as industrial waste heat, biomass, and geothermal heat, which are less susceptible to grid volatility. A central thermal energy plant serving multiple buildings can operate more efficiently than individual systems by smoothing overall energy demand across varied consumption patterns, thereby reducing total energy use and minimizing the need for costly peak capacity. Additionally, TENs can significantly lower peak space heating, cooling, and water heating demands—even during extreme temperatures—resulting in a flatter electricity demand curve compared to conventional HVAC systems like air-source heat pumps (ASHPs) or electric resistance heating. In community-scale applications, ground source heat pumps (GSHPs) can further enhance performance by storing thermal energy in the ground (thermal banking), enabling strategic load shifting away from peak hours.

6. ~~*The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals;*~~

7. ~~*Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;*~~

8. *Funding opportunities and cost recovery mechanisms, including, but not limited to:*

    a. *Leveraging applicable tax credits and other federal assistance;*

    While federal tax credits exist, policy incentives at the state and local levels are often geared toward individual building owners rather than multi-unit/building developments. The absence of targeted policies or funding programs for community-scale systems makes TENs less financially attractive to builders.

    CLEAResult developed a grant and incentive tracker for GEGP and GETCO applicants that could be paired with state incentives to reduce GHG emissions, increase energy efficiency and cost savings. The tracker includes specific information on state, federal, local and utility programs that applicants can leverage to support TEN projects or other geothermal energy projects. The State of Maine could look to do something similar to encourage new developments to take advantage of state and federal opportunities to offset costs.

~~b. Funding from the New England Heat Pump Accelerator;~~

~~c. The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and~~

d. Rebates for heat pumps through the Efficiency Maine Trust;

Please refer to our responses for other questions, particularly under 8.a.

9. The role thermal energy networks can play in increasing the affordability of housing, development and energy;

TENs can play a role in improving housing affordability and advancing development by delivering low-cost, reliable, and efficient heating and cooling at a community scale. TENs can dramatically reduce overall energy consumption and operating costs, lowering utility expenses for residents, and reducing dependence on fossil fuels. With long lifespans, minimal maintenance, and eligibility for renewable energy incentives, TENs are a stable, cost-effective solution for affordable housing and mixed-use developments.

Beyond cost savings, TENs drive local economic and environmental benefits. The installation of TENs can contribute to the local economy with skilled local jobs and increase energy resilience by providing consistent performance year-round. TENs contribute to climate and equity goals by enabling decarbonized heating and cooling in equity priority neighborhoods. For example, the State of Colorado incorporated diversity and inclusion criteria in their evaluation of applications for incentive programs and initiatives for TEN installations, giving applicants who represent a minority business or intend to install TEN systems in a Disproportionately Impacted/Disadvantaged Community a higher score which could result in a higher award amount—ultimately reducing the upfront cost for developers that may be passed down to owners/tenants.

For programs that CLEAResult is supporting in the State of Colorado, a Community Engagement Plan and Risk Mitigation Plan from all applicants are required to ensure that community members were involved from project inception through installation and any potential risks were identified to avoid unanticipated harm to local communities. The application also contained questions about the benefits provided to the local/surrounding community including workforce development support, economic benefits, etc. which also resulted in a higher application score.

10. Additional considerations including:

a. Technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks;

Many builders, contractors, and design engineers have little experience with TEN design and installation, and some hold outdated or inaccurate assumptions about their cost and complexity. This knowledge gap leads to hesitation and missed opportunities during project planning. Providing third party technical assistance and/or evaluation ensures that the customer is receiving accurate and adequate support when evaluating potential TEN designs and comparing them to conventional systems. In retrofit situations, a hybrid approach between TENs and conventional design may yield optimal cost and energy savings.

Since Maine experiences a very high heating to cooling ratio, using renewable sources to provide supplemental heating can help reduce the cost of TENs. Small scale waste digesters, wastewater heat recovery, and passive solar water heating are some examples that can be effectively integrated with a TEN.

~~*b. Lifetime and annual project cost-effectiveness, including assumptions, of thermal energy networks;*~~

c. Explain the applicability, benefits, challenges and scalability of thermal energy networks to various geographic regions in Maine (e.g., urban, rural, remote, etc.);

Please refer to our responses for other questions, particularly under 10.d.

d. Outline any considerations for new construction or retrofit projects adopting networked geothermal;

The main barriers to adopting TENs in new construction, particularly in residential sector, are primarily non-technical. The technology itself is proven, reliable, and capable of delivering long-term energy and emissions savings, but widespread implementation is hindered by financing models, developer incentives, and institutional familiarity. In most cases, the obstacles stem from how projects are planned, financed, and regulated—not from the performance or feasibility of the systems themselves. Addressing these systemic challenges is key to unlocking the full potential of TENs in new and existing developments.

- **High Upfront Costs**: The excavation and pipeline installation required for TENs add expense compared to conventional HVAC systems. Since developers often focus on keeping initial construction costs low to maintain market competitiveness and profit margins, long-term (i.e., operational) energy savings do not offset the higher upfront investment in their decision-making. Mainstream adoption of disclosure practices and/or requirements regarding the energy consumption of such buildings may help address at least some hesitation among developers about making upfront investments, as this will valorize future energy savings for building owners, and therefore, justify higher prices of facilities connected to TENs.
- **Split Incentives Between Developers and Owners/Tenants**: Developers bear the cost of installing TEN infrastructure, while building owners benefit from lower utility bills over time. This misalignment means developers have low financial motivation to include TENs unless they can recoup the cost through higher sale prices or incentives. Mainstream adoption of disclosure practices and/or requirements regarding the energy consumption of such buildings may help address at least some of this misalignment, as this will valorize future energy savings for building owners, and therefore, help developers justify higher prices of facilities connected to TENs. This issue is especially exacerbated for renters in multi-unit dwellings.
- **Financing and Valuation Gaps:** Many lenders and appraisers do not yet recognize the added value of TEN systems, making it difficult for developers to secure financing or justify higher building prices. The lack of standardized methods for valuing future energy savings further limits adoption.
- **Utility and Regulatory Barriers:** Utilities often lack clear policies for supporting, interconnecting, or owning shared thermal systems, and building codes rarely address community-scale thermal systems explicitly. As a result, developers may face uncertainty, delays, or inconsistent permitting requirements.
- **Coordination Challenges for Shared Systems**: In developments with a TEN, questions arise around ownership, maintenance, and billing. Determining whether the system will be managed by an HOA, utility, third-party provider, or else adds administrative complexity that developers may wish to avoid.
- **Lack of Regulatory Clarity**: Utilities, as natural monopolies, operate under an "obligation to serve" clause, which requires them to provide and maintain service to all customers who request it. This clause also mandates that utilities provide an equivalent service when an existing one is changed or terminated (e.g., electricity and steam replacing natural gas). Electricity, steam, and natural gas are often not considered interchangeable services, wherein each service must be provided adequately and are governed under their own separate regulatory frameworks. This creates challenges for developers, particularly when converting or renovating buildings with energy/fuel infrastructure. While most TENs are privately owned and operated at the institutional level (e.g., industrial organizations, academic campuses) for their own use that renders "obligation to serve" clause irrelevant in their cases, places like New York City depends on steam from local combined heat and power (CHP) plant owned and operated by the local utility, ConEdison, for the operation of a city-wide TEN. Greater clarity (or modification) of the "obligation to serve" clause could significantly reduce risk and accelerate the adoption of TENs.

~~e. The safety, reliability, and resiliency of thermal energy networks during both normal operations and during outages or extreme weather;~~

~~f. Utility ownership, regulatory and cost allocation/recovery frameworks that may be applicable to thermal energy networks, including frameworks that currently exist in Maine law; and~~

11. Any additional information relevant to the scope of this RFI.

When designing program materials for future funding, CLEAResult would encourage GEO/DOER to consider the following four aspects of a well-designed TEN grant program:

- **Support Community-Scale Systems.** GEO/DOER should allow for shared-loop or networked ground source heat pump (GSHP) systems. These systems reduce per-unit installation costs, improve thermal efficiency, and are ideal for campuses, neighborhoods, and mixed-use developments.

- **Fund Pre-Development Feasibility Studies.** Offering grants or cost-sharing for early-stage activities—such as thermal conductivity testing, borehole mapping, and site-specific modeling—can help developers make informed go/no-go decisions and avoid costly missteps.

- **Balanced Application Process.** GEO/DOER should aim for a balanced application process that provides enough guidance and structure to ensure high-quality proposals, without overwhelming potential applicants. If too much information is required upfront (e.g., detailed engineering specs, full site surveys), smaller developers or community groups may be discouraged from applying. On the other hand, if too little information is requested, it increases the risk of funding poorly conceived or infeasible projects. A phased application process—starting with a short concept proposal followed by a more detailed submission or quarterly/annual reporting for shortlisted applicants—could strike the right balance.

- **Set Clear Expectations.** GEO/DOER should ensure that all documents required in an application are clearly described and, where possible, accompanied by specific examples or templates. Providing detailed explanations of what constitutes an acceptable document – such as sample forms, annotated examples, or common mistakes to avoid – helps applicants understand expectations and reduces the risk of incomplete or incorrect submissions. This approach promotes fairness and efficiency by allowing all applicants, regardless of prior experience, to have an equal opportunity to meet each requirement successfully. Clear guidance minimizes administrative delays, decreases the need for submissions, and enhances the overall quality and consistency of applications received.

To: Maine Department of Energy Resources at doer@maine.gov
From: International Brotherhood of Electrical Workers local union 1253 (IBEW 1253)
Re: Thermal Energy Network RFI

Thank you for the opportunity to provide comments on the RFI to inform the potential creation of a thermal energy networks program for Maine.

IBEW 1253 is a union of more than 300 construction electricians with a jurisdiction that spans from Eastport to Rockland along the coast and inland from Lincoln to Jay. Our members build hospitals, schools, solar fields, and wind towers.

IBEW 1253's response to RFI:

1) Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country.

Thermal Energy Networks (TENs) are one of the lowest-emission and most efficient technologies available to heat and cool buildings.[1] They allow for the exchange of heat with a number of sources, such as lakes and rivers, energy intensive buildings like data centers, wastewater systems, or even the stable temperature of the earth, and can be designed with backup systems to remain reliable even amid a power outage. TENs can operate in residential, commercial, and industrial contexts for building heating and cooling purposes, and community and utility-scale pilots typically take advantage of mixed-use environments to efficiently balance diverse heating and cooling needs across users connected to the system. At scale, thermal energy networks can efficiently serve an entire neighborhood's heating and cooling needs without the use of fossil fuels.

To date, twelve states have passed significant legislation that take steps toward advancing TENs, with several more introduced or pending. This includes eight states that have passed legislation authorizing or requiring IOUs to develop thermal energy network (UTENs) pilots. Currently at least 20 utility thermal energy network pilot projects are operating or under development across five states.[2] These pilots in development serve a wide range of building types with various system configurations including systems serving mixed-used neighborhoods, public housing complexes, and projects that integrate data centers to beneficially utilize waste heat. In addition to utility projects, several states are also advancing thermal energy networks as a key strategy for efficiently decarbonizing large state facilities. For example, New York State has directed the New York Power Authority to develop "Decarbonization Action Plans" for the fifteen highest emitting state-owned facilities in New York State, and in FY2025 has enacted a

[1] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[2] States with utility TENs pilots under development include New York, Massachusetts, Minnesota, Colorado, and Maryland.

budget that includes at least $200 million for the most shovel-ready thermal energy network projects at these facilities.[3]

In addition to being highly efficient and facilitating the decarbonization of buildings at a neighborhood-scale, TENs also have significant high-road and union job creation potential. Because of the similarities between TENs and natural gas distribution infrastructure, these systems require the same skills of the highly trained workforce currently employed in the construction, operation, and maintenance of the gas system. Thermal energy networks can be constructed most safely, efficiently, and cost-effective by leveraging this existing trained workforce and ensuring strong labor standards for thermal energy network construction and operation. Maine's clean energy and workforce transition must ensure an abundance of high-quality clean energy positions. In order to protect workers from a loss in living standard, and to retain and grow a skilled clean energy workforce necessary to meet future labor demand, new clean energy jobs must provide the same high-quality employment and benefits for workers as those experienced by the existing unionized energy workforce. Low-road clean energy jobs hurt workers, working families, and communities—they also lead to low-quality installations which hinder the potential success of the industry. One recent example of a low-road installer hindering current Maine policy is Pine Tree Solar, a company in Hermon, ME, that has been sued more than a dozen times since June 2023 for issues such as not completing work or failing to refund money.[4] Their bad actions slowed Maine's statutorily mandated attempt to decarbonize. Another example is the cable company subcontractor who died while installing fiber-optic cable to aid Maine's policy goal of connecting every Mainer to high-speed internet.[5] This not only slowed Maine's attempt to meet its policy goal, much more importantly a worker lost their life. Successful thermal energy network deployment with strong labor standards will not only leverage the existing skilled utility workforce, but can also be a major driver of high-quality clean energy jobs in the buildings sector.

3) Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;

A significant challenge for thermal energy network development is scaling utility systems, without placing an undue burden on the broader ratebase to cover the upfront costs of these projects. One area of opportunity is developing utility programs and new financing mechanisms that enable cost-sharing between the system customers and the utility, particularly for behind-

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[3] New York's $4.2 billion Environmental Bond Act, passed in 2022, provides funding for state agencies, local governments, and other partners to adapt to climate change, improve resiliency, and create green jobs. As part of this initiative, the Governor announced $150 million in grants to decarbonize New York State's public college campuses, including through the installation of TENs. Press Release, Governor Hochul Announces $150 Million Investments in Clean Water, Clean Air and Green Jobs Environmental Bond Act Funding to SUNY and CUNY Campuses, N.Y.S. (Feb. 12, 2025), https://www.governor.ny.gov/news/governor-hochul-announces-150-million-investments-clean-water-clean-air-and-green-jobs?utm_source=chatgpt.com.

[4] https://www.bangordailynews.com/2025/10/06/bangor/bangor-police-courts/pine-tree-solar-sued-again/

[5] https://www.live5news.com/2023/01/18/subcontractor-dies-after-fall-bucket-lift-police-say/

the-meter upgrades. For example, a significant portion of Eversource's Framingham, Massachusetts pilot project costs resulted from covering all behind-the-meter construction, including appliance installation, but also necessary electrical upgrades and abatement of environmental hazards such as mold and asbestos.[6] In contrast is National Grid's pilot under development in Boston, Massachusetts which will serve several Boston Housing Authority (BHA) buildings in the Dorchester neighborhood. While National Grid will construct, own and operate a horizontal distribution loop and thermal borefield to serve the buildings, BHA will fund and conduct all behind-the-meter work, such as appliance installations, weatherization, and other upgrades of their buildings necessary to connect to the thermal energy network as part of their broader decarbonization mandate. Through this cost-sharing model, BHA can invest in the most clean and efficient heating and cooling system for their residents, and National Grid ratepayers will not be on the hook for 100% of project costs.

While programs that can braid together a wide range of funding sources– including tax credits, rebates, and low-income weatherization assistance programs – to fund needed building improvements are critical, state thermal energy network programs can also prioritize utility projects that allow for these kinds of cost-sharing with customers through some of the following strategies:

- *Authorizing utility pilots with public customers:* States may authorize or require rate-based utility pilots where utilities own and operate the front-of-meter infrastructure, while public building owners may pay the costs of behind-the-meter improvements necessary to electrify their heating and cooling and interconnect their buildings with the utility systems as in case of the National Grid pilot in Boston.
- *Mandating utility pilots in public buildings:* In establishing mandatory utility TENs pilot programs, states may also specify customer types, including the requirement that a minimum number of pilots proposed by each utility serve public building customers. This can provide the same cost-sharing benefits as the previous model, while ensuring that utilities pursue these public--private partnerships.
- *Utility-owned TENs paid for exclusively by large campus customers:* Some states, including Massachusetts[7], are also exploring new models of utility TENs ownership where a utility owned and operated TEN could serve a single large campus customer, which would pay the utility back for all system costs over time. This could, for example, increase access to and lower upfront costs for TENs for colleges and universities by allowing them to pay for these systems over time, while limiting the impact of utility TENs development on other ratepayers, who would not bear the costs of these systems serving large campus customers.
- *Establishing broadly available financing for residential and small commercial customers to pay back behind-the-meter improvements as part of a TEN overtime on their utility bill:*

[6] Building Decarbonization Coalition. "Case Study: Framingham, Massachusetts." https://buildingdecarb.org/resource/case-study-framingham-massachusetts
[7] Massachusetts introduced 2025 H4144 "Energy Affordability, Independence & Innovation Act."

Some states are also exploring utility-financed upgrades, including a model known as "Inclusive Utility Investment", which allows individual customers to pay back energy efficiency and other upgrades over time on their utility bills from energy savings.[8] This model could increase access to residential upgrades, while minimizing the impact of UTENs on the broader rate base.

Finally, utilization of the incumbent utility workforce and enforcement of strong labor standards are also essential to gain cost efficiencies for thermal energy network construction, operation, and maintenance. Proper installation of heat pumps and other energy efficiency improvements is essential to ensure functional performance and that these systems deliver on their efficiency and energy savings benefits over the full lifetime of the equipment.[9] The existing utility workforce is also best equipped to safely and efficiently deliver utility-scale TENs infrastructure, which requires many of the same skills such as excavation, drilling, pipelaying, pipe fusing and pipefitting. By establishing strong labor standards for thermal energy network development, Maine can protect consumers and ensure properly operating and cost-efficient systems.

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

Thermal Energy Networks (TENs) are one of the cleanest and most efficient technologies available to heat and cool buildings[10] and investing in electrification through geothermal heat pumps can produce significant energy demand and cost savings. According to the U.S. Department of Energy, geothermal systems can reduce energy consumption by approximately 25% to 50% compared to air source heat pump systems. Geothermal heat pumps reach high efficiencies (300%-600%) on the coldest of winter nights.[11] A 2023 report from Oak Ridge National Lab also concluded that mass deployment of geothermal heat pumps across the US would reduce transmission expansion requirements 33-38%, an amount equating to roughly 24,500 miles of avoided transmission.[12] Transmission is one of the primary drivers of energy costs in Maine – in New England, annual transmission charges have grown to $3.3 billion, from $869 million in 2008[13] and in January Central Maine Power Co. customers began paying 7%

[8] Energy Star. "Inclusive Utility Investment."
[9] Pacific Northwest National Laboratory, DOE Building Technologies Office and Earth Advantage. "Energy Skilled: Preparing the Workforce for a Clean Energy Future"
[10] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[11] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[12] Oak Ridge National Laboratory. November 2023. "Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States."
[13] UtilityDive. November 19, 2024."Not just a 'boondoggle': State regulators, industrial companies push for cost effective transmission"

more in their monthly bills Jan. 1 to help fund $3.3 billion of upgrades to transmission lines.[14] Investing in highly efficient building decarbonization through geothermal heat pumps and thermal energy networks can significantly reduce peak demand and associated expensive grid build-out.

6) The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals;

Across the country buildings are responsible for nearly 31% of greenhouse gas emissions (GHG) when including electricity usage.[15] Reducing GHG emissions from buildings is an essential component in helping to meet Maine's statutory emissions reduction goals, and TENs are perfectly suited to help meet these goals.

Maine's state goals for emissions reductions are enshrined in law[16] as follows:

1. By 2030, the State shall reduce gross annual greenhouse gas emissions to at least 45% below the 1990 gross annual greenhouse gas emissions level.
2. By 2040, the gross annual greenhouse gas emissions level must be on an annual trajectory sufficient to achieve the 2050 annual emission level goal.
3. By 2050, the State shall reduce gross annual greenhouse gas emissions to at least 80% below the 1990 gross annual greenhouse gas emissions level.

In addition, by 2045, net annual greenhouse gas emissions may not exceed zero metric tons.

Maine law also requires the prioritization of emissions reductions by sectors. In particular, Maine law prioritizes those sectors that are the most significant sources of greenhouse gas emissions as identified by the United States Energy Information Administration, and in the Maine Department of Environmental Protection's (DEP) biennial reports.[17]

Although Maine has recently made progress towards its greenhouse gas emissions reduction goals, according to the DEP's latest report, the residential and commercial sectors remain

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[14] Portland Press Herald. January 7, 2025. "Maine electricity bills increased again this month."
[15] U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022. https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.
[16] Maine Revised Statutes, title 38, § 576 (2023). Retrieved from https://legislature.maine.gov/statutes/38/title38sec576.html; see also Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals (2024) (released June 10, 2024), available at https://www1.maine.gov/dep/news/news.html?id=12801571 (last visited Oct. 2, 2025).
[17] Maine Revised Statutes, title 38, § 576-A (2023). Retrieved from https://legislature.maine.gov/statutes/38/title38sec576-A.html.

significant contributors to Maine's gross GHG emissions.[18] In both the commercial and residential sectors, space heating and cooling are commonly responsible for contributions to Maine's greenhouse gas emissions, mostly as a result of delivered fuels such as home heating oil.[19] Using TENs would help Maine meet our established goals for emissions reductions because they are the most climate-friendly, highest efficiency option for space heating and cooling in residential and commercial settings, and TENs projects can create high-quality union jobs.

Across Maine, TENs are likely to be the best option for lowering emissions in both commercial and residential space heating and cooling. Fundamentally, TENs will often be the most efficient option available for both energy savings and functionality, if properly installed.[20] This higher efficiency, along with their direct applicability to some of the most difficult to decarbonize sectors in Maine – residential and commercial space heating and cooling – means TENs must be part of Maine's plan to meet its goals. Maine must include TENs as part of its plan to meet its emissions goals, and we should also ensure proper installation of TENs by requiring the use of well-trained, highly skilled workers working under robust safety and labor standards. We will only meet our state's climate and clean energy goals if TENs systems are built properly with a well-trained, experienced and qualified workforce. And if we do, TENs present an enormous opportunity to help Maine achieve our GHG emissions goals, in part because if TENs are installed at scale and by the proper workforce, we will buy time for the renewable energy transition to continue. Our current energy generation infrastructure will have less strain on it if we are using the most efficient methods for heating and cooling our buildings. Reductions in emissions from power plants that receive less call for power will help us get to our goals while continuing to use some legacy energy sources.

7) Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;

Maine should ensure widely-accepted, reasonable, and appropriately high labor standards on TENs to establish a pipeline of work for a trained workforce and ensure workers are not left behind.

TENs represent an exciting opportunity in Maine, not only for the emissions reductions they represent, but also for the creation of high-quality union careers for Maine's local workforce. As Maine develops TENs for our public buildings, through the state's public utilities, or across the

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[18] Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals Appendix A, Table A4..

[19] Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals, Appendix C.

[20] Pacific Northwest National Laboratory, DOE Building Technologies Office and Earth Advantage. "Energy Skilled: Preparing the Workforce for a Clean Energy Future"

state writ large, it is imperative that strong labor standards are applied to these important projects.

Strong labor standards would ensure that TENs projects create quality jobs for Mainers, and also ensure that, as with incumbent workers in the unionized gas industry, Mainers get trained with the skills necessary for proper installation. At base level and in an attempt to avoid potentially dangerous corner-cutting when it comes to the cost and quality of labor, the construction of TENs projects across Maine should meet or exceed prevailing wage rates and benefits. Further, Maine must incorporate certified pre-apprenticeship and registered apprenticeship utilization standards to ensure that we create a robust and sustainable pipeline of well-trained, highly-skilled local workers available for TENs construction. These standards would also ensure projects qualify for the IRA's Investment Tax Credit, which applies to qualifying geothermal projects and survived the most recent changes made in Public Law 119-21 in July 2025[21]. Maine should also apply licensing and certified contractor requirements for both behind-the-meter and front-of-meter work. Given the complexity and sensitivity of subsurface work in existing utility rights-of-way, TENs work in Maine should include Operator Qualification standards similar to and as required in the natural gas industry, as well as explore the applicability of related standards and/or licensing for equipment operators in the industry.

As the demand for TENs increase across the country, the demand for the highly skilled workers that construct TENs projects will also increase.[22] Thus it is all the more important that Maine require the use of certified pre-apprenticeship programs, registered apprenticeship programs and licensing standards in the construction and operations of TENs. These standards would establish a pipeline of work – a necessary precondition for training programs to invest in skilling up workers who would otherwise not be available to do this work. Without such standards, Maine may end up with a shortage of trained workers able to do drilling, pipelaying, and looping, electrical work, HVAC installation and servicing – which could end up costing Mainers in the long run. In addition, Maine should require that these projects – which often require the excavation or use of publicly owned land — pay the prevailing wage and benefits rate.

It is important to note the installation and maintenance of TENs require similar skill sets to those used by unionized trades employed in the construction, maintenance, and operation of the existing gas distribution system. High labor standards would ensure that these workers are positioned to be part of the workforce for TENs projects. Without high labor standards on TENs projects Maine risks putting these workers into a race to the bottom, or even leaving them behind. Instead, through the application of high labor standards, we can ensure Maine workers

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21 Text - H.R.1 - 119th Congress (2025-2026): One Big Beautiful Bill Act | Congress.gov | Library of Congress

22 Home Energy Efficiency Team. Workforce Transition. https://www.heet.org/workforce-transition.

continue to have family-sustaining wages and benefits, high safety standards and union careers as they build out TENs projects across Maine.[23]

In addition to prevailing wage and apprenticeship utilization requirements, it is essential that labor standards baked into the framework for TENs in Maine ensure a just and equitable transition and continuity of job quality for incumbent workers in the natural gas industry who will be directly impacted by the state's building decarbonization policies. This should apply to both workers who currently construct gas systems as well as utility workers who operate and maintain those systems, and is essential for continuity of job quality and retaining a highly skilled workforce. New York's UTENs legislation has some of the strongest and most effective standards to ensure that proposers of pilot TENs projects ensure that the incumbent gas utility workforce is highly prioritized for any TENs construction, operation or maintenance.[24]

8) Funding opportunities and cost recovery mechanisms, including, but not limited to: a) Leveraging applicable tax credits and other federal assistance; b) Funding from the New England Heat Pump Accelerator; c) The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and d) Rebates for heat pumps through the Efficiency Maine Trust;

According to the U.S. Department of Energy, although the upfront cost of installing a geothermal heat pump system is more expensive than installing an air source system of the same heating and cooling capacity, the additional cost can typically be recouped in energy savings in just 5 to 10 years.[25] These systems also tend to last longer and require less maintenance than air source heat pumps.[26]

In addition to their inherent cost-saving potential due to high efficiencies and low maintenance costs, commercial geothermal heat pumps and thermal energy networks are the only space heating and cooling technology that continue to be eligible for federal clean energy tax credits, and utilities and public entities can still access these credits through 2035 to cover a significant portion of TENs project costs. These credits are enhanced by meeting prevailing wage, apprenticeship, domestic content and energy community requirements, and some states have mandated that utilities maximize federal funding opportunities in development TENs pilots in order to limit potential impacts to ratepayers.[27]

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[23] Understanding Thermal Energy Networks. Cornell ILR, 2024, https://www.ilr.cornell.edu/sites/default/files-d8/2024-12/understanding-thermal-energy-networks.pdf.
[24] https://www.nysenate.gov/legislation/bills/2021/S9422
[25] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[26] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[27] Maryland HB 397 "WARMTH Act." Enacted in 2024.

Residential geothermal heat pump installations as part of TENs can also leverage available rebates through Efficiency Maine Trust. Maine could also require utilities to establish new accessible financing mechanisms, such as “Inclusive Utility Investment” programs that could facilitate affordable energy efficiency upgrades and heat pump installation. These programs can also facilitate more effective and equitable cost-sharing between individual customers connected to a TEN and the broader rate base when developing TENs.[28]

Finally, Maine can leverage additional low-cost public financing to support TENs development, particularly projects serving public entities such as state facilities, schools, and public housing developments. Several states have established grant and low-interest loan programs to facilitate TENs development through their state green banks, power authorities, and energy offices including Illinois[29], New York[30], Colorado[31], and Connecticut[32].

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

- **Affordability for ratepayers**: Thermal energy networks can provide clean and affordable energy. Ground source heat pumps are highly efficient requiring less electricity use than other traditional electric technologies while also lowering impacts to the grid. An Oak Ridge National Laboratory study found that the deployment of large-scale ground source heat pumps (which could be connected to a thermal energy network) required less grid infrastructure, and the cost saved from spending on grid infrastructure upgrades could reduce the cost of power for all grid consumers.[33]
- **TENs on new residential construction:** Thermal energy networks on new construction can make housing development more affordable. TENs in new construction are more cost-effective compared to retrofitting existing building stock, which would require additional energy efficiency and weatherization retrofits to install the proper heat pump.
- **Utility driven TENs with public customer**: Cost-sharing models between a utility and public customers can help alleviate ratepayers from covering all upfront costs associated with a TENs project. Through a cost-sharing model, public customers can cover project costs associated with the behind-the-meter work while the utility covers project costs associated with the front-of-the-meter, which would most likely be rate-based. These types of partnerships can make TENs projects on residential buildings more feasible and more affordable. There are some examples of this model in New York

[28] Energy Star. “Inclusive Utility Investment.”
[29] Illinois Finance Authority/Climate Bank. Climate Pollution Reduction Grant Community Geothermal Planning + Pilots program.
[30] NYSERDA. Large Scale Thermal Program.
[31] Colorado Energy Office. Geothermal Energy Grant Program.
[32] Connecticut. Thermal Energy Network Grant and Loan Program.
[33] Oak Ridge National Laboratory. Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States. November 2023. Pg. xii.

and Massachusetts. Through New York's utility TENs pilot program ConEd is working to integrate New York City Housing Authority properties into a TEN. Another example of this model and partnership with public customers includes the National Grid, a utility in Boston, and the Boston Housing Authority.

RFI responses provided by WaterFurnace International are highlighted in BLUE text.

GEO/DOER requests written public comments on the following topics as called for by the Resolve. Responses must be in the form of written comments and submitted electronically to doer@maine.gov on or before October 17, 2025, by 4:00 p.m

1) Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;

> Numerous examples of Thermal Energy Networks are identified and outlined by the Building Decarb Coalition on their website. This is a fairly comprehensive collection of emerging and completed projects: https://buildingdecarb.org/neighborhood-scale-projects-map
>
> There are several commercial geothermal projects described on the Department of Energy website that are useful to be familiar with: https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-studies
>
> Finally, these case studies on the WaterFurnace website offer a variety of applications and strategies for thermal systems that deploy renewable energy ground source heat pumps: https://www.waterfurnace.com/commercial/why-waterfurnace/spotlights#casestudies

2) The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:

a) Geophysical considerations;

> Many Thermal Energy Network projects are determined to be impractical in the earliest design stages due to a lack of understanding or awareness of other options within the traditional building design and engineering firms.
>
> Like many commercial projects that are cooling dominant (even in Maine) one recent project in Kansas City reduced the size and cost of the loop field by 30% simply by adding domestic water heating to the design. Additional operation savings across 500 living units will exceed $100,000 per year.
>
> Additionally, projects are often deemed unfeasible early on because of the anticipated cost of the underground infrastructure, or ground heat exchanger. Surprisingly, it is not uncommon to see large investments in vertical bore holes adjacent to storm water retention ponds that could provide equal, or better, heating and cooling capacity for less than 1/50th of the cost.

b) Compatibility with incumbent air source heat pumps and other heating, ventilating and air conditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network;

The process of selecting the right type of ground source heat pump is a major blind spot for most utility TENs teams. The right type of equipment will significantly lower the cost of the project in terms of design, installation, labor, performance, and reliability. Considerations of how to merge a ground source heat pump with an existing hydronic, or ducted, or other systems has to start as early as site selection. It's critical to engage an experienced, neutral, and skilled "owner's representative" before site selection and then to follow his/her guidance.

c) Permitting and right-of-way considerations;

d) Constraints around geographic density; and

Geographic density is both an advantage and a potential disadvantage. It's critical to identify intersections with existing infrastructure during site selection. Although TENs are typically very simple closed loop, non-pressurized, fresh water systems constructed of inert materials like HDPE, it is critical to avoid costly work arounds with city water, sewage, power, fiber, or gas utilities.

In a site like the Commercial Street in Downtown Portland district, for a familiar example, there are major advantages including:

- Numerous customers can be linked together with minimal network size.
- Additionally, the bulk of the area is adjacent to an ideal heat source and sink, Portland harbor. (Potentially, no vertical drilling required.)
- Finally on the plus side, the variety of businesses in this area provide substantial load diversity to minimize network loading and therefore cost. Waste heat from ice plants and food storage can be used to heat apartments, retail, and restaurants. And vice versa.
- Electrical infrastructure in an area like this is already equipped to provide air conditioning. Therefore, there is more than enough power at each individual meter to support conversion to a ground source heat pump.

Disadvantages to consider in an area like Commercial Street include:

- Minimal "open space" for vertical drilling (if necessary). This might cause vertical boreholes to be drilled in the public right-of-way, like the street. And that's a challenge for project managers.

- Hundreds of years of uncharted below ground infrastructure. There may be 18th century stone structures ten feet below grade or even sacred burial grounds. Historic districts present all sorts of unexpected issues.
- This is a busy place. It's hard to construction where there is heavy vehicle, rail, marine, and foot traffic.

e) Other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks;

- Simultaneous heating and cooling offset the "net demand" on a TEN by sharing heat among these sources and sinks.
- Because the ground water temperature in Maine is relatively low and saturated at upper levels, the potential for extremely low-cost heat pump operation is high.
- Diurnal switching from heating to cooling and back is common in shoulder seasons in Maine. This is ideal for a TEN which operates as a high inertia thermal battery. In other words, a frosty October night in Maine would draw heat from a TEN while network customers heat the water and air in their homes and buildings. Later on that same day when the sun heats up the buildings and the air to, say 84°F, the sheer volume of water in the TEN would reabsorb that heat easily without significantly tapping the ground source. This quickly reversing battery effect is substantial and drives efficiencies even higher.

3) Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;

Start small. Maybe 100 or fewer nodes. Less than 3 acres. Minimal infrastructure disruption. Green field is easiest.

Use experts. And check them with other experts.

Put the medicine where the pain is. In order, it usually makes sense to start with delivered oil, then propane and firewood, then electric resistance, then natural gas and air-source heat pumps.

Employ repeatable solutions with equipment. Variety is more expensive.

Find willing tenants and owners before starting.

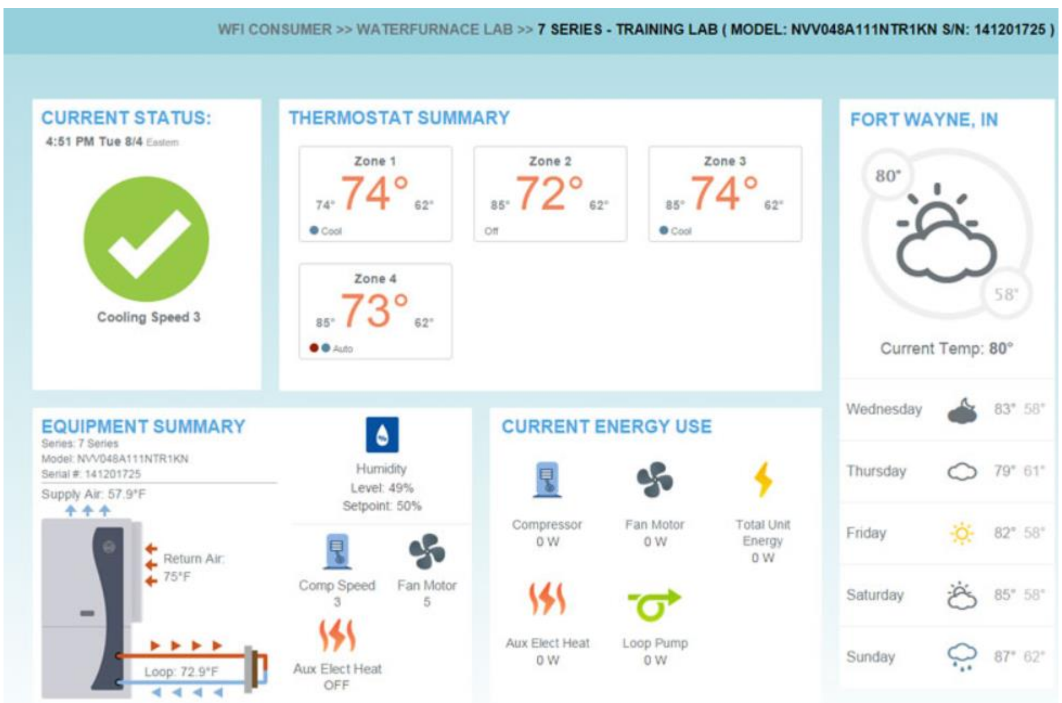
Recover costs at a rate that can be reconciled with coincident savings. “My heat pump saves me $100/month and the utility is only charging me $80/month.”

Operating data from a heat pump is critical information that demonstrates the benefits of the TEN to all stakeholders. It is used for troubleshooting, refrigeration system monitoring, and energy monitoring. This is also critical data for commissioning and project acceptance. Below are a few images of data capture that are provided from ground source heat pumps as a standard feature and at no charge to the customer.

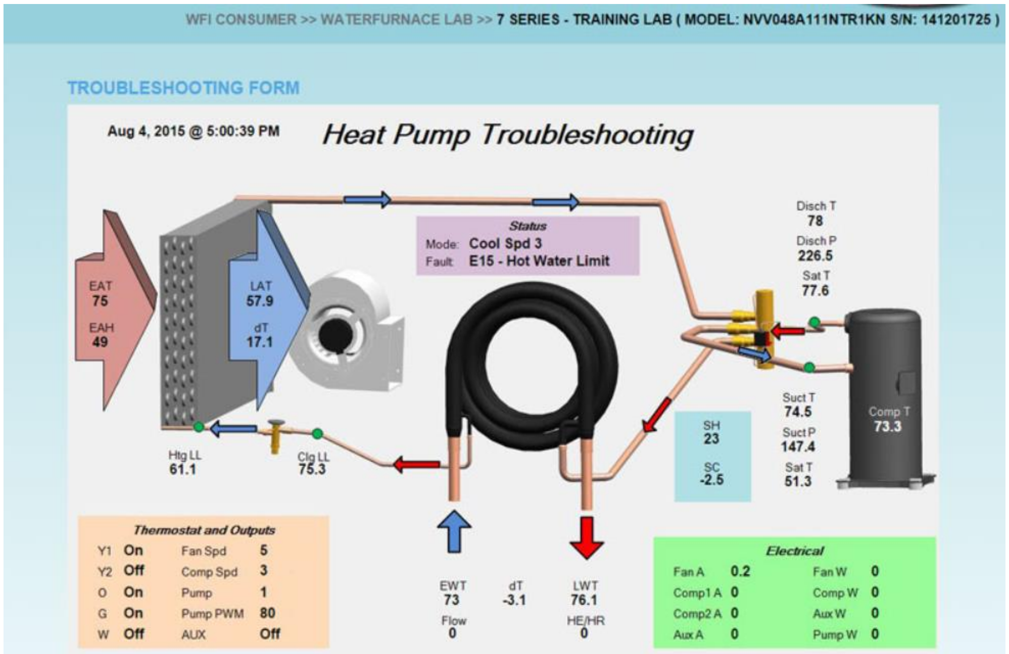
*** Key Note ***

TEN owner access to private user data has to be planned and negotiated prior to project execution. Retroactive access to data is problematic legally and practically.

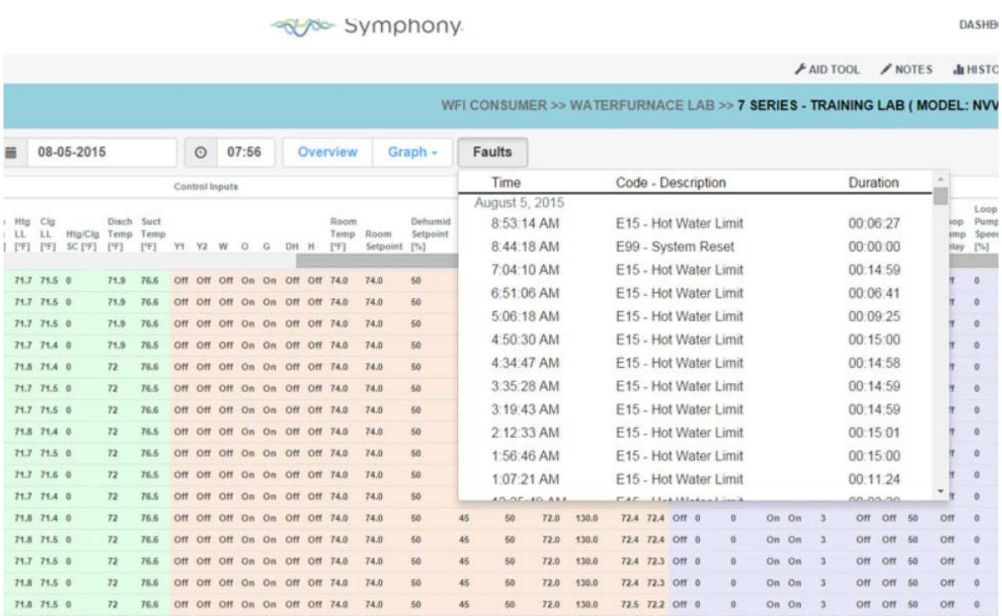
Basic Tenant/Owner View (Updated every 10 seconds)



Troubleshooting chart (Updated every 10 seconds)



Historical Data Capture (Updated every 10 seconds)



4) Life-cycle costs and benefits of commercially available or emerging thermal energy network technologies, including comparisons to incumbent heating and cooling technologies appropriate for the Maine climate;

Closed Loop Ground Heat Exchangers should last well in excess of 100 years. This is the same HDPE pipe the gas industry depreciates for 80 years or more, but without the high fluid pressures.

Surface water closed loops are equally durable. The pond loop at the WaterFurnace factory in Fort Wayne, IN (-20°F to 100°F) has been in situ for over 30 years requiring zero maintenance and having no measurable impact on the eco system.

Extended range ground source heat pumps should last in excess of 25 years with minimal maintenance.

Typical ground source heat pumps should be comparable in cost to high efficiency air source heat pumps with similar compressor and air side technology.

Most important for Maine: Whether it's -20°F or 100°F the performance of a heat pump on a TEN is unaffected. While air-source heat pumps lose substantial capacity AND efficiency at high and low ambient temperatures, TENs heat pumps are unaffected.

A 10-year-old air-source heat pump has lost 5-10% efficiency and capacity due to external fouling and corrosion of the outdoor heat exchanger. Salt air, smoke, compressor vibration, dirt, and various animal contributions all combine to reduce the ability of the outdoor system to lose its ability to function as designed. None of that applies to a TENs heat pump; they are unaffected by outdoor elements.

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

Studies and observations of ground source heat pumps over the years have revealed substantial grid peak benefits over other sources of heating and cooling.

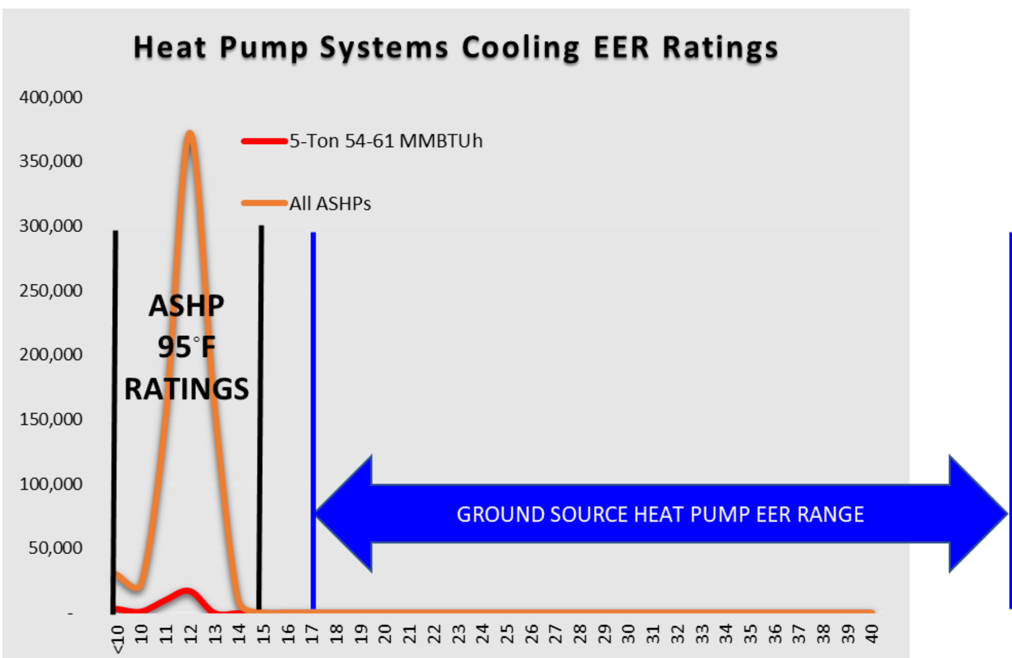
In a nutshell:

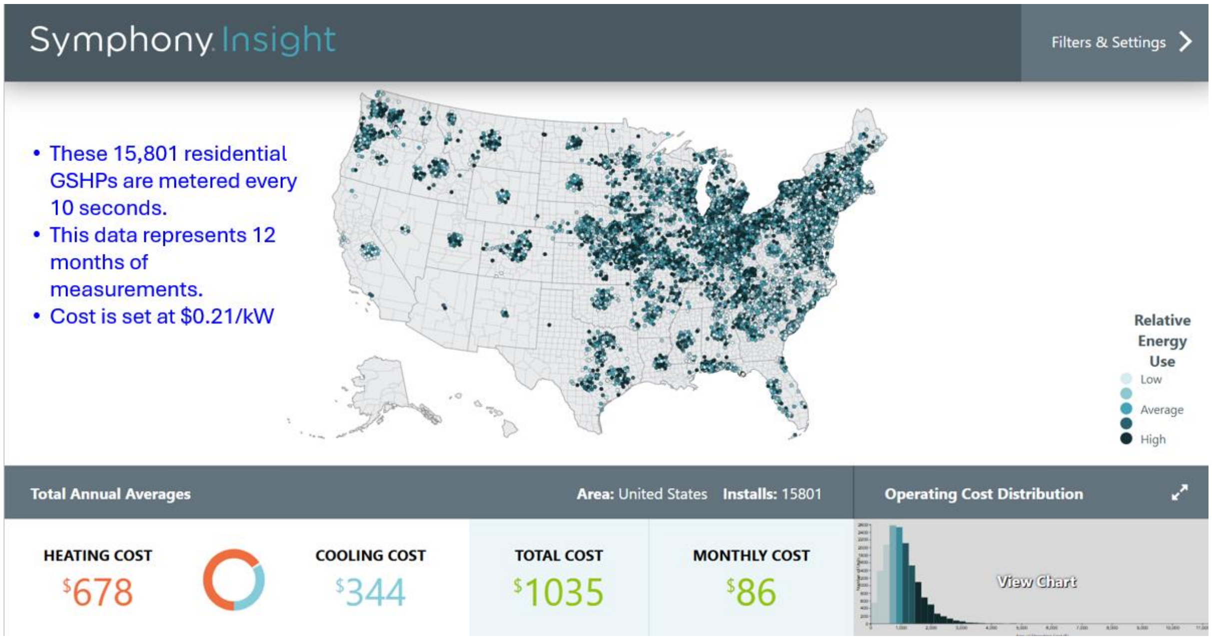
- GSHPs reduce peak load cooling by 0.6 kW per installed ton of capacity. (**1,667 Tons of TENs or geothermal reduces summer peak load 1MW**.)
- When replacing electric resistance heat, GSHPs use roughly one fourth of the required power, at any time. Shifting from a COP of 1.0 to 4.0 or higher. On a TEN these COPs can be even higher due to load diversity.

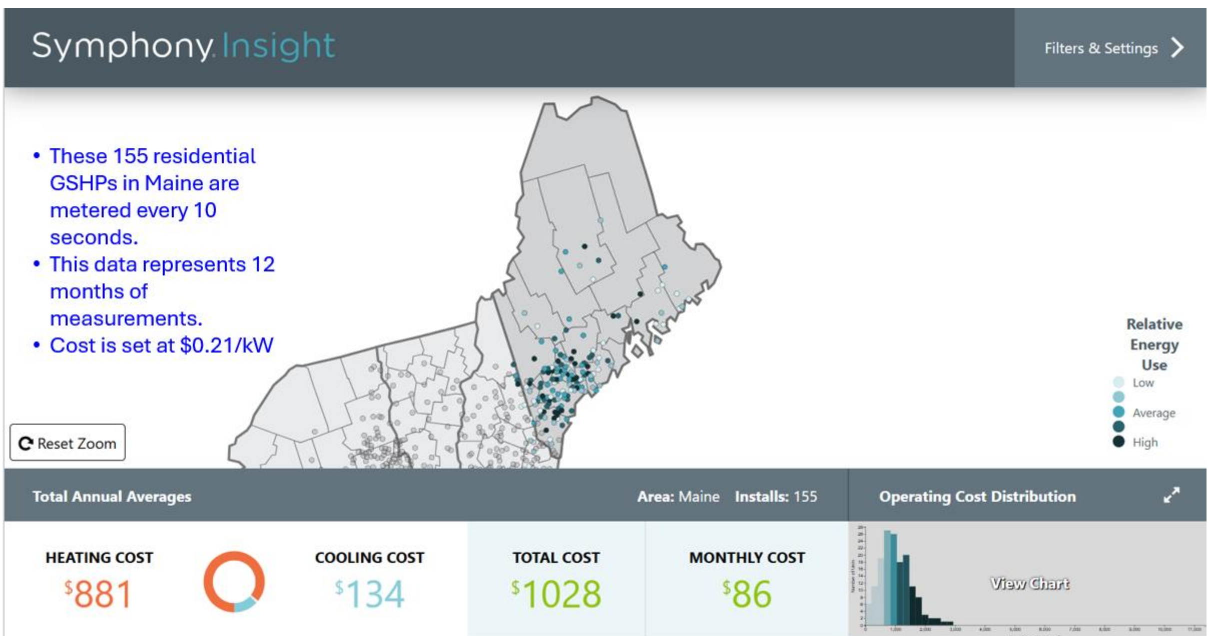
- Here's the most surprising thing: A TENs heat pump may use less electricity than a legacy forced air furnace throughout the course of a heating season.
- Typical ducted heat pumps in Maine are installed with electric strip heat back up systems to provide capacity at low temperatures and offset the cooling delivered during defrost cycles. These electric heaters in Maine range from 7.5 to 30kW for 2-5 Ton systems. Because most ducted heat pumps in Maine are operate with 30 or 60 minute defrost cycles selected by the installers (to avoid call backs) the grid is routinely impacted by 2-5 times the typical load expected of a heat pump at the worst possible time.
- Ground source heat pumps, like those on a TEN, *NEVER DEFROST*. Although many ground source heat pumps in Maine are installed with supplemental electric strip heat, this is not necessary particularly on a TEN. Where they are installed, WaterFurnace monitoring data indicates they never turn on or are only used for a few hours a year.

Several images to illustrate this:

This 2023 chart shows cooling peak load energy efficiency ratios of all 5- Ton ASHPs & GSHPs.




Symphony Insight
Filters & Settings
• These 15,801 residential GSHPs are metered every 10 seconds.
• This data represents 12 months of measurements.
• Cost is set at $0.21/kW
Relative Energy Use
Low
Average
High
Total Annual Averages
Area: United States Installs: 15801
Operating Cost Distribution
HEATING COST
$678
COOLING COST
$344
TOTAL COST
$1035
MONTHLY COST
$86
View Chart


Symphony Insight
Filters & Settings
• These 155 residential GSHPs in Maine are metered every 10 seconds.
• This data represents 12 months of measurements.
• Cost is set at $0.21/kW
Reset Zoom
Relative Energy Use
Low
Average
High
Total Annual Averages
Area: Maine Installs: 155
Operating Cost Distribution
HEATING COST
$881
COOLING COST
$134
TOTAL COST
$1028
MONTHLY COST
$86
View Chart

6) The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals3;   3 38 MRSA §576-A 3 | Page

7) Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;

> Start by training the TENs project team in GSHP technology. Using IGSHPA certified training curricula will provide a broad background and credible testing for certification. https://igshpa.org/training-certification/ The TENs team will be enabled to ask the right questions and provide a State of Maine workforce gap analysis.
>
> In the end, ground source heat pumps are actually easier to install and require fewer skills. They are typically factory charged and have sealed refrigerant systems. Most ground source heat pump systems can be remotely controlled, adjusted, and analyzed for maximum operational efficiency. Conventional systems require field charging, gas furnace valve adjustments, and defrosting set up. None of that is required with a TENs heat pump.

8) Funding opportunities and cost recovery mechanisms, including, but not limited to:

- a) Leveraging applicable tax credits and other federal assistance;
- b) Funding from the New England Heat Pump Accelerator;
- c) The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and
- d) Rebates for heat pumps through the Efficiency Maine Trust;

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

> A TEN to provide a typical family of four with renewable heating, cooling and hot water can provide monthly savings between $100 and $250. Because of the extended equipment lifespan, this will also save that family a re-investment of $12,000 to $20,000 every 10-15 years. These saving can be the difference between a perpetual renting cycle and the equity building opportunity to own a home.

10) Additional considerations including:

a) Technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks;

In Maine where Heating to Cooling operates at a 9:1ratio, it would likely make financial sense to supplement TENs with external renewable heating sources to reduce cost and complexity of the network. This could be as simple as passive solar water heating, organic digesters, or wastewater heat exchangers.

b) Lifetime and annual project cost-effectiveness, including assumptions, of thermal energy networks;

Project cost-effectiveness is entirely dependent on the site selection, the technology selection, and how well the system is managed for cost and quality in front of the meter.

In general, however, behind the meter, every standalone family property should generate annual savings in the range of $1,000 to $3,000. Monetizing a more finely tuned estimate of behind the meter savings against in front of the meter costs is the simplest way to estimate financial efficacy.

Lifetime benefits will be highly dependent on the time window used in the calculation. It isn't likely that 80-year depreciation schedules like the gas industry are necessary, but it would be reasonable to use a 100-year TEN lifecycle.

c) Explain the applicability, benefits, challenges and scalability of thermal energy networks to various geographic regions in Maine (e.g., urban, rural, remote, etc.);

Just one lifetime ago it would have seemed ridiculous to propose Maine install over 1,500 miles of highly pressurized natural gas pipelines or over 100,000 miles of fresh water pipelines (with over 18,000 made of lead!), and yet today that is the case.

Scalability of TEN in Maine may be impractical in, say Allagash or the Pemigewasset wilderness due to remoteness and terrain. However, downtowns, sub-urban, and even semi-rural areas in Maine are entirely possible. Perhaps, as possible as providing drinking water, electricity, natural gas, or even fiber optics.

d) Outline any considerations for new construction or retrofit projects adopting networked geothermal;

New construction is typically the lowest cost for a TEN because it allows for simultaneous excavation for the TEN and other site prep.

For retrofit, start at the point of application and work backwards. For instance, a modern home or building with a complete network of ducts, a utility space, and air conditioning makes for an easy application. Alternatively, a 100-year old warehouse or uninsulated wood frame house with no air conditioning or ductwork present a long list of challenges that can't be fixed by any kind of heat pump. All of these issues will substantially impact the size, cost, and complexity of the final product.

e) The safety, reliability, and resiliency of thermal energy networks during both normal operations and during outages or extreme weather;

A TEN requires electricity to operate, so outages can be challenging in that regard. HOWEVER, it is critical to emphasize the resilience of a TEN in the face of fires, flooding, drought, extreme heat, cold, and extended periods of unfavorable weather. Below 10 meters depth, Maine's soil, lakes, and coastal waters are a non-intermittent source of renewable energy unaffected by seasonality or anticipated 100-year climate change.

f) Utility ownership, regulatory and cost allocation/recovery frameworks that may be applicable to thermal energy networks, including frameworks that currently exist in Maine law; and

The first TEN project in Maine will be difficult and may not be financially favorable in the short term. It may be necessary to pay for equipment behind the meter as well as the TEN itself. The Eversource team on the Framingham project has extensive understanding of what work and doesn't work. In addition, there are many things they will do differently on their next project that we can all learn from.

https://www.youtube.com/shorts/woEjGoaftNQ
https://www.youtube.com/watch?v=igxg-FCB-aY&t=11s

https://www.youtube.com/watch?v=JDTIPQ3sSNI

11) Any additional information relevant to the scope of this RFI.

When the Pine Tree State decides to execute an energy program, it has demonstrated wherewithal needed to succeed for many years. Applying that same leadership and resolve to TENs will go a long way toward a more energy secure Maine for generations to come.

Maine Thermal Energy Networks Program

Response to Request for Information

Resolves 2025, ch. 67 (LD 1619)

Prepared for: Maine Governor's Energy Office / Maine Department of Energy Resources
Prepared by: Solen Works

- Michael Pulaski, PhD – Co-Founder
- Gunnar Hubbard, FAIA, LEED Fellow – Co-Founder

Date: October 17, 2025

Executive Summary

Maine stands at a critical juncture in its energy transition. Based on direct project experience and case studies presented here, we believe thermal energy networks represent not just a viable option but the optimal infrastructure solution for achieving Maine's building decarbonizations while simultaneously improving energy affordability, grid resilience, and economic development.

Solen works was founded by industry pioneers Michael Pulaski and Gunnar Hubbard to help accelerate climate positive change and innovation in the built environment. With over 50 years of combined experience consulting with some of the most progressive institutions, developers, architects and engineers in the region and throughout the world, we are excited to bring forward and share critical lessons learned, case studies, thoughts and ideas on how Maine can become a leader in developing an innovative and practical Thermal Energy Network program.

The Technology is Proven

Six case studies analyzed in this report—spanning Sweden, British Columbia, Maine and the northeastern United States—demonstrate consistent technical performance with heat pump coefficients of performance between 3.0 and 5.0, greenhouse gas reductions of 25 to 80 percent versus fossil fuel baselines.

Princeton's transformation from century-old steam infrastructure to 2,000+ geothermal bores serving 180 buildings demonstrates that even complex institutional retrofits are technically and financially feasible. Whistler's wastewater heat recovery system providing 95 percent of heating needs in a mountain climate validates the approach for Maine's municipal treatment plants. These projects aren't experiments—they're operational infrastructure serving real buildings.

Maine is Exceptionally Well-Positioned

We've identified some of Maine's strategic advantages. Fifty-eight municipal wastewater treatment plants process sufficient flow to provide recoverable thermal energy, with Portland's East End facility alone offering megawatts of continuous capacity—enough to potentially serve thousands of housing units. The state's geology ranges from sedimentary bedrock along the coast for shallow geothermal systems, to granitic formations inland with excellent properties for future enhanced geothermal applications. Dense urban cores in Portland, Bangor, and Lewiston-Auburn provide prime opportunities. Institutional campuses at UMaine, Bowdoin, Colby, and state government facilities provide ideal anchor loads.

The Flexible Interconnection Game-Changer

A critical innovation summarized in this document is integration of flexible interconnection principles articulated by Jigar Shah, former director of DOE's Loan Programs Office. Traditional interconnection processes assume new loads must be accommodated at full capacity under all conditions, requiring costly grid upgrades and multi-year approval timelines. Flexible interconnection enables projects to connect much quicker by accepting limited curtailment during rare grid constraint periods—perhaps 50 to 400 hours annually out of 8,760 total.

Thermal networks are ideally suited for this approach. The thermal mass of buildings provides 12 to 24 hours of inertia. Ground-source systems store weeks or months of thermal capacity. Tank storage adds hours of buffering. Pre-heating during off-peak periods builds thermal reserves before anticipated constraint periods. Rather than being constrained by grid limitations, thermal networks become grid assets—providing flexibility services, supporting renewable energy integration, and deferring infrastructure upgrades while accelerating their own deployment timeline.

New buildings built in thermal energy districts can act as **energy hubs**, providing all the centralized distribution equipment, thermal energy storage and controls systems required to manage large districts or a series of smaller independent neighborhood district systems.

The hard parts are coordination and policy. Navigating utility interconnection, aligning stakeholder incentives, securing financing, coordinating construction with municipal infrastructure projects, training operations staff, and establishing customer service protocols require sustained attention. These are solvable challenges—but they require dedicated project management and stakeholder facilitation that technical consultants alone don't provide.

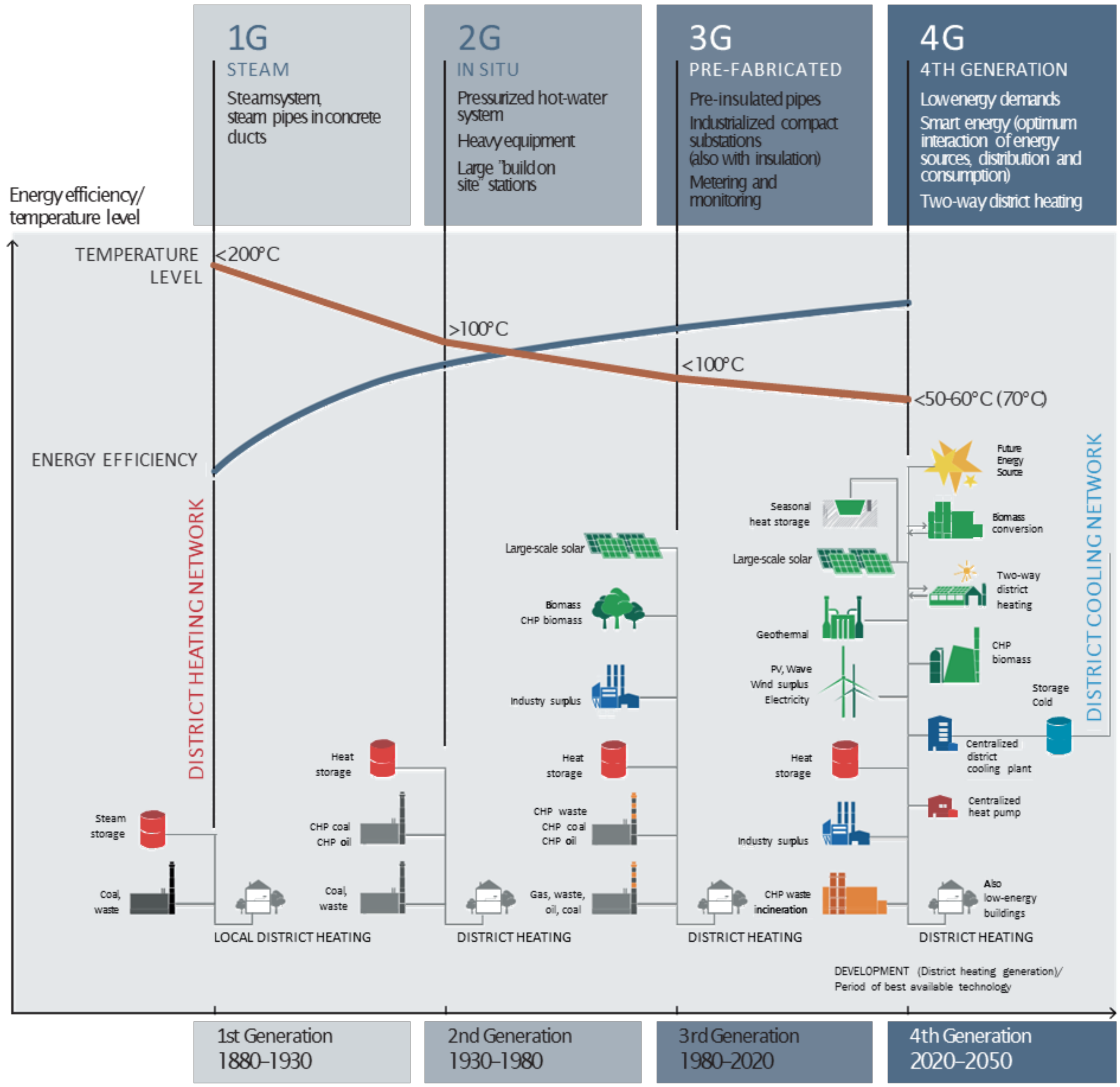
Pilots must be genuine demonstrations. Too often, "pilots" are designed for minimum viable functionality rather than optimal performance. That approach generates mediocre results that undermine broader adoption. Maine's pilots must be excellence demonstrations, designed, properly commissioned, comprehensively monitored—that generate compelling data for scaling.

Overview of District Thermal Energy Systems

District thermal systems distribute heating and cooling from centralized or shared sources through networks of insulated piping to multiple buildings. While the concept dates to the late 19th century, modern systems have evolved dramatically in efficiency, flexibility, and environmental performance. Understanding this evolution is essential to appreciating why **fourth-generation thermal networks** represent the optimal technology for Maine's building decarbonization strategy.

First or second generation district systems, still common in older urban cores, use steam or high-temperature water with supply temperatures of 180 to over 220 degrees Fahrenheit. These systems were designed around centralized generation from fossil fuel boilers or combined heat and power plants, with radial distribution to end users. While effective for their time, third-generation systems suffer from high thermal losses of 15 to 25 percent, inability to efficiently integrate renewable energy sources, and capital-intensive centralized infrastructure. Third-generation systems improved on this model by reducing distribution temperatures, lowering losses and enabling better integration with solar thermal and waste heat sources, but still required centralized thermal generation.

Fourth-generation district energy systems represent a fundamental departure from the centralized generation model. These networks distribute water at ambient temperature, typically 50-70 degrees Fahrenheit, to building-level heat pumps that provide the final temperature lift for space heating or cooling. This architecture enables several critical advantages. First, low distribution temperatures result in minimal thermal losses of less than 5 percent even over extended distribution distances. Second, the ambient temperature allows bidirectional energy sharing: waste heat from buildings requiring cooling can simultaneously warm the network for buildings requiring heating, dramatically improving system efficiency. Third, the low temperature enables integration with diverse thermal sources including shallow geothermal systems, wastewater heat recovery, surface water exchange, and industrial process waste heat that would be unsuitable for higher-temperature networks. Fourth, the distributed heat pump architecture provides resilience, as building systems can continue operating even if portions of the network experience issues.



Source: Aalborg University and Danfoss District Energy, 2014

The thermodynamic principles underlying fourth-generation systems center on the heat pump cycle and the concept of coefficient of performance. A heat pump uses electrical energy to move thermal energy from a lower temperature source to a higher temperature sink for heating, or vice versa for cooling. The coefficient of performance is the ratio of useful thermal energy delivered to electrical energy consumed. For heating, COPs typically range from 3.5 to 5.0, meaning that for every kilowatt-hour of electricity consumed, 3.5 to 5.0 kilowatt-hours of heating are delivered to the building. This represents a dramatic improvement over combustion heating systems that achieve efficiencies of 0.7 to 0.85 due to stack losses and distribution losses.

The performance advantage of ground-coupled or water-source heat pumps compared to air-source systems becomes especially pronounced in cold climates like Maine's. Air-source heat pumps must extract heat from outdoor air that may be well below freezing during peak heating periods, resulting in COP degradation to 1.8 to 2.5 and requiring periodic defrost cycles that further reduce delivered capacity. In contrast, a heat pump connected to an ambient loop maintained at 50 to 60 degrees Fahrenheit by ground coupling or wastewater heat recovery operates at consistently high COP throughout the winter, providing both better economics and more reliable heating capacity during the coldest periods when it's most needed.

System efficiency is further enhanced through optimization of the temperature differential between supply and return. Most fourth-generation networks target a delta-T of 8 to 16 degrees Fahrenheit, which balances pumping energy against thermal capacity. Too small a delta-T requires high flow rates and pumping power; too large a delta-T reduces heat pump performance as source temperatures decline. Detailed hydraulic modeling during system design establishes the optimal balance for each specific network configuration.

Thermal storage represents another key enabler of system performance and grid integration. Storage can occur at multiple scales: the ground itself serves as seasonal thermal storage through borehole thermal energy storage, where summer heat rejection is stored for winter extraction; tank storage provides diurnal shifting, charging during off-peak hours when electricity prices and grid carbon intensity are lowest; and the thermal mass of buildings provides several hours of buffering capacity. This inherent storage capability positions thermal networks as ideal candidates for grid flexibility services, a concept explored in detail in subsequent sections.

Case Studies: Lessons from Leading Thermal Networks

The following case studies demonstrate the technical and economic viability of district thermal systems across diverse settings, with direct relevance to Maine's climate, institutional landscape, and building stock. Each provides specific insights into design approaches, performance metrics, governance structures, and lessons learned that can inform Maine's deployment strategy.

Malmö Bo01 (Sweden)

The Bo01 district in Malmö represents one of Europe's most ambitious sustainable development projects, transforming a former industrial waterfront into a mixed-use neighborhood of 1,300 residential units and 12,000 square meters of commercial space. Completed in 2001 as Sweden's housing exposition, the district incorporated an integrated energy strategy centered on renewable resources and energy efficiency. The thermal system combines aquifer thermal energy storage, solar thermal collectors covering 3,000 square meters of roof area, and wind power purchased through green electricity certificates.

The district energy system operates as a low-temperature network with supply temperatures of 85 to 120 degrees Fahrenheit, substantially lower than traditional Swedish district heating systems. Heat pumps at building substations provide the final temperature boost for domestic hot water and space heating. The aquifer storage system stores excess solar thermal energy captured during summer months for extraction during winter, effectively providing seasonal thermal storage. This configuration achieves system COPs of 3.5 to 4.5 across the heating season, delivering primary energy ratios of 0.68 compared to 1.2 for conventional gas boiler systems.

Malmo Sweden:

B001 Malmo the first climate-neutral district in Sweden.

It uses 100% renewable energy.

Energy is supplied by solar and wind power systems and geothermal heat pumps.

Rooftops incorporate living roofs, solar power systems, or both.

The buildings that feature solar power systems, the sun supplies both electricity (photovoltaics) and hot water (solar hot water), feeding into the district heating system.

The offshore Lillgrund Wind Farm, with 48 large wind turbines generates 2.3 MW of electricity, enough to power 60,000 homes.

Recyclable and organic materials are sorted and contribute to energy production by the city's biogas plant.(world's largest biogas plant)

The area also offers an extensive bike path system and buses that are powered by natural gas/biogas.

The governance model involves municipal ownership of the distribution infrastructure through the city's energy utility E.ON Malmö, with building-level systems owned and maintained by building associations. This split ownership model has proven effective, clearly delineating responsibilities while ensuring professional operation of the network. For Maine, Bo01's coastal location, maritime climate, and integration of solar thermal and aquifer storage provide direct precedents for areas like Portland's Eastern Waterfront development area, where similar wastewater and seawater resources exist alongside planned mixed-use redevelopment.

Princeton University (New Jersey)

Princeton University's transition from a century-old steam distribution system to a modern ground-source heat pump network represents the largest institutional retrofit of its kind in North America and provides crucial lessons for Maine's campus-scale opportunities. The university operated a centralized coal and later natural gas-fired steam plant serving more than 180 buildings across 15 million square feet. By 2012, the system required major infrastructure renewal, with steam tunnels, piping, and building systems at end of life. Rather than rebuilding another generation of steam infrastructure, the university pursued a transformational approach: decommissioning the steam plant entirely and converting to electrified heating and cooling through ground-source heat pumps.

The technical solution involved installing more than 2,000 geothermal boreholes across campus at depths of 600-800 feet. These closed-loop wells circulate water through a new district system suppling chilled water and medium-low temperature hot water, which was selected to interface with existing building heating systems designed for higher temperature water, reducing building-side retrofits. As buildings undergo major renovations, they transition to lower temperature hydronic systems or direct expansion heat pump systems that can utilize even lower distribution temperatures.

The phased implementation approach proved critical to success. Rather than attempting campus-wide conversion simultaneously, Princeton implemented the system over ten years converting buildings incrementally as their existing systems required major maintenance or replacement. This staged approach maintained campus operations throughout the transition, allowed contractors and staff to build expertise progressively, and spread capital costs over multiple fiscal years. Each building conversion included detailed commissioning and performance verification to ensure heat pump systems were properly sized and controlled before proceeding to the next phase.

For Maine, Princeton demonstrates that large institutional retrofits are technically and financially feasible, with direct applicability to the University of Maine's Orono campus, Bowdoin, Colby, and state government facilities in Augusta.

Confidential College, (Maine)

A recently completed a feasibility study for a college in Maine that explored a neighborhood geothermal district system that connected 9 large houses (between 5,000-10,000 sf). Most of the houses were built in the early 1900s and required renovation in conjunction with energy efficiency improvements. The study evaluated the total operating costs for 45 years comparing the business-as-usual case vs a series of energy improvements with a centralized geothermal based plant serving the buildings.

More information about this study can be available upon request and with the owner's permission to share the data, however it represents an interesting neighborhood scale example of how a small-scale district system could be implemented in neighborhoods throughout Maine.

Confidential Private School Campus (New Hampshire)

A study performed for a private boarding school in New Hampshire provides a compelling example of phased decarbonization for historic campus environments similar to many of Maine's secondary schools and small colleges. The 2,000-acre campus includes approximately 90 buildings ranging from modern dormitories to historic structures dating to the 19th century.

The decarbonization approach is planned in three phases. Phase one focused on building envelope improvements and controls optimization, reducing base energy demand before converting heating systems. This included window replacement, insulation upgrades where structurally feasible in historic buildings, LED lighting conversion, and implementation of building automation systems with occupancy-based controls. These measures and others are estimated to reduce campus energy use intensity by approximately 20 percent, setting the stage for more cost-effective electrification.

Phase two involves installation of ground-source heat pump systems serving clusters of buildings. Approximately 300 geothermal bores at 500-foot depth provide thermal source for distributed water-to-water heat pumps. The design maintains existing hydronic distribution within buildings while replacing boilers with heat pumps, minimizing disruption to occupied spaces. Proposed thermal storage tanks provide load shifting capability and peak demand management. Backup propane boilers are retained temporarily for peak periods and emergency backup, providing reliability during the transition.

For Maine, the study provides a direct precedent for secondary schools statewide including private schools like Hebron Academy, Gould Academy, and Maine Central Institute, as well as public consolidated high schools. The emphasis on envelope improvements before heating system conversion represents important sequencing that improves overall project economics. The retention of backup systems during transition provides operational flexibility and stakeholder confidence.

Roux Institute at Northeastern University (Portland, Maine)

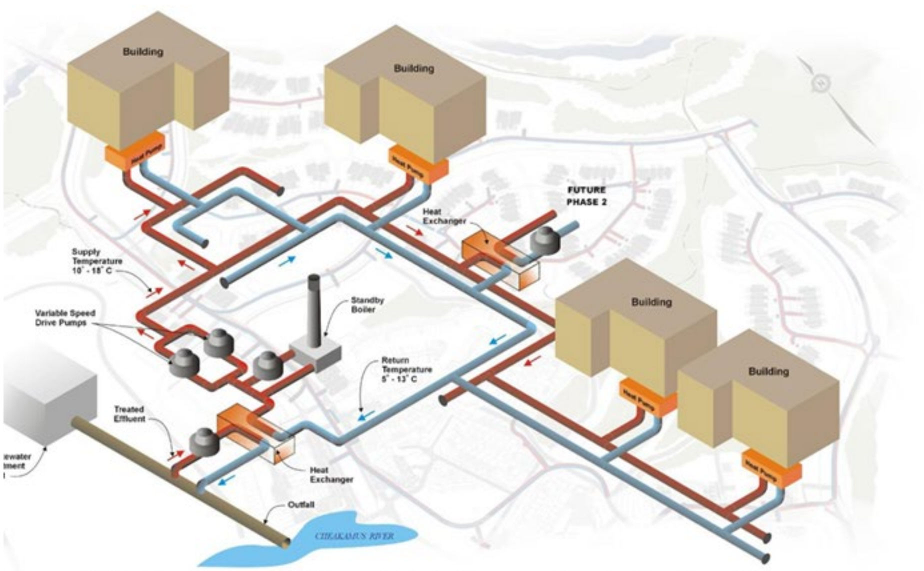
Located on Portland's waterfront, the new Alfond Center is 245,000 sf of new construction was designed for aggressive energy performance, targeting 30 percent better than code requirements with 100 percent electric systems and no fossil fuel infrastructure. Eighty-two geothermal wells are installed to 500-foot depth in the bedrock underlying the site to serve the academic building.

During the study phase a campus approach was studied that modeled a fourth-generation system that incorporated a seawater heat exchanger system to draw water from Casco Bay, pass it through plate heat exchangers for fouling resistance, and return it with minimal temperature change to the harbor. The two systems feed into a common ambient temperature loop circulating at 50 to 70 degrees Fahrenheit, from which building heat pumps draw heating or reject cooling loads. In the end the seawater system was not incorporated due to the cost of the system and the quantity of stainless steel piping and material required.

Whistler Athletes' Village (British Columbia)

The Whistler Village District Energy System provides crucial lessons about wastewater heat recovery in a cold mountain climate, directly relevant to Maine municipalities with wastewater treatment plants near downtown cores. Constructed for the 2010 Winter Olympics as athlete housing and subsequently converted to workforce housing, the neighborhood includes 250 residential units served by an innovative wastewater-source district energy system.

The technical approach extracts thermal energy from treated wastewater effluent after final treatment but before discharge to the river. Heat exchangers with specialized coatings to prevent biofouling transfer thermal energy from the wastewater stream at approximately 54 to 70 degrees Fahrenheit to the district loop circulating water. The temperature drop in the wastewater is limited to less than 4 degrees Fahrenheit to ensure no impact on downstream aquatic habitat, a regulatory requirement that establishes the thermal capacity available from the wastewater stream. Despite this constraint, the wastewater provides approximately 95 percent of the neighborhood's annual heating needs, with electric resistance backup serving only the coldest peak days.



Whistler Athletes' Village District Energy-Sharing System Schematic
Two-pipe closed loop can provide both heating and cooling.

The governance model involves municipal ownership through the Resort Municipality of Whistler, with thermal service provided to building owners as a regulated utility service similar to water and sewer. This integration makes operational sense given the wastewater facility is municipally owned and operated.

The success of the initial installation led to system expansion, with the network growing to serve approximately 750 units by 2023 through extension of distribution piping to adjacent neighborhoods. This staged expansion validated the scalability of the approach and demonstrated growing community acceptance as early adopters experienced reliable, affordable service. Operational experience over 15 years has refined maintenance protocols, particularly quarterly heat exchanger cleaning to maintain thermal performance despite biological growth on wastewater-side surfaces.

For Maine, Whistler's demonstration of wastewater heat recovery in a cold climate with peak winter temperatures similar to inland Maine validates the technology's applicability. Portland, Bangor, Lewiston and Augusta all represent opportunities for similar systems. The municipal ownership model also aligns well with Maine's tradition of municipal utilities and public infrastructure ownership. **The key requirement is proximity of the wastewater facility to dense heat demand,** a condition satisfied in all four Maine cities where treatment plants are located within one mile of downtown cores or dense institutional clusters.

Flexible Interconnections: Accelerating Deployment Through Grid Integration

A critical barrier to deploying new electrified heating systems including district thermal networks has been the lengthy timeline for grid interconnection studies and infrastructure upgrades. Traditional interconnection processes assume new loads must be accommodated at full capacity under worst-case conditions 24 hours per day, 365 days per year. When local distribution circuits approach capacity constraints, utilities require expensive upgrades to transformers, feeders, and substations before allowing new connections, with timelines extending three to eight years. This creates a fundamental mismatch: thermal systems can be designed and constructed in 18 to 24 months, but grid interconnection approval may take longer than building the system itself.

Jigar Shah, former director of the Department of Energy's Loan Programs Office and a leading voice in clean energy deployment, has articulated a transformative approach called flexible interconnection that resolves this timing mismatch. The core principle is elegant: rather than requiring grid infrastructure upgrades to accommodate new loads under all possible conditions, utilities can grant earlier interconnection approval if load operators agree to accept conditional curtailment during rare periods of grid stress. The insight is that distribution constraints are episodic rather than constant, occurring perhaps 20 to 100 hours per year during coincident peak demand on hot summer afternoons or cold winter mornings. By accepting limited curtailment during these infrequent constraint periods, projects can interconnect immediately using existing infrastructure capacity.

The flexible interconnection framework establishes a different planning paradigm. **Instead of utilities studying worst-case scenarios and sizing interconnections for theoretical maximum load that may occur only a few hours annually, the analysis focuses on available grid capacity under realistic operating conditions.** Utilities provide time-varying interconnection limits to connected loads, updated on a rolling 24 to 48 hour forecast basis, that reflect actual grid conditions. During constrained periods, connected loads receive signals to reduce consumption, with the magnitude and duration of reduction specified in the interconnection agreement. This approach fundamentally shifts from binary yes-or-no interconnection decisions to a spectrum of interconnection capacities that vary based on grid conditions.

District thermal systems are ideal candidates for flexible interconnection due to their inherent thermal storage capacity and load flexibility. The thermal mass of buildings connected to a district network provides 12 to 24 hours of thermal inertia, meaning indoor temperatures change slowly even if heating or cooling is interrupted. Ground-source heat pump systems have additional thermal storage in the ground itself, with bore fields providing weeks or months of thermal capacity. Tank storage can be added economically to provide additional buffering. This storage enables pre-heating or pre-cooling during off-peak periods when grid capacity is abundant and electricity prices are low, building up thermal reserves before anticipated constraint periods.

The integration of flexible interconnection principles into Maine's thermal network program could accelerate deployment, reduce total system costs through avoided utility upgrades, and position thermal systems as grid assets rather than mere loads.

Environmental Benefits and Life-Cycle Analysis

The environmental case for thermal energy networks extends beyond operational carbon reductions to include air quality improvements, water quality benefits, and resource conservation. A comprehensive life-cycle analysis considers both the **embodied carbon** in system construction and the **avoided emissions** over decades of operation, demonstrating strongly positive net environmental benefits.

Construction of thermal networks involves embodied carbon in materials and construction processes that must be considered in net environmental accounting. Geothermal bores involve steel casing, HDPE piping, cement-based grout, and diesel fuel for drilling equipment. Distributed piping, compressors, heat exchangers all have embodied carbon emission to be accounted for, as well as refrigerant leaking over system lifespan.

Conclusions and Recommendations

District thermal energy networks represent a strategic technology for Maine to achieve building sector decarbonization in alignment with statutory emissions reduction goals while simultaneously advancing energy affordability, grid resilience, and economic development objectives. The convergence of technical maturity demonstrated through successful deployments across diverse climates, federal funding availability through the Inflation Reduction Act and other programs, Maine's abundant thermal resources including wastewater heat recovery and geothermal capacity, and policy momentum created by LD 1619 establishes a unique opportunity for Maine to lead the nation in modern thermal network deployment.

The case studies analyzed spanning Sweden, British Columbia, and the northeastern United States demonstrate consistent technical performance with heat pump coefficients of performance of 3.0 to 5.0, greenhouse gas reductions of 25 to 80 percent versus fossil fuel baselines. These systems operate successfully in climates comparable to or more severe than Maine's, using thermal resources Maine possesses in abundance.

The **flexible interconnection framework articulated** by Jigar Shah and detailed in this report represents a critical innovation enabling faster deployment while providing grid benefits. Rather than requiring multi-year grid upgrade processes before connecting new loads, flexible interconnection allows thermal networks to connect conditionally by accepting limited curtailment during rare constraint periods. The thermal storage inherent in district networks makes them ideal candidates for this approach, transforming potential grid challenges into flexibility assets that support renewable energy integration and defer costly infrastructure upgrades.

Stakeholder engagement including municipalities, utilities, building owners, community organizations, and the public must build understanding and support for thermal networks as new infrastructure. Education about costs, benefits, operations, and customer experience will be essential to achieving connection rates necessary for project viability. The pilots themselves will serve as demonstrations building confidence for subsequent expansion.

Prepared by Solen Works
October 17, 2025

Appendix: Technical References

Case Study Sources:

- City of Malmö Energy Department, "Bo01 District Energy Performance Report" (2018)
- Princeton University Facilities, "Geothermal Energy System Overview" (2023)
- Whistler Village District Energy Award Summary, 2013

Technical Standards:

- ASHRAE, "District Heating and Cooling Guide," 4th Edition (2021)
- International Ground Source Heat Pump Association, "Closed-Loop Design Standards" (2020)

- International District Energy Association, "Best Practices Guidelines" (2022)

Maine Policy Documents:

- Maine Climate Council, "Maine Won't Wait: Climate Action Plan" (2020)
- 38 MRSA §576-A (Emissions Reduction Targets)
- 35-A MRSA §10128 (Thermal Energy Investment Program)
- Resolves 2025, ch. 67 (LD 1619)

Grid Integration:

- U.S. Department of Energy, "Flexible DER & EV Connections" (July 2024)
- Environmental Defense Fund, "Flexible Interconnection for EV Infrastructure" (January 2024)
- Multiple sources documenting Jigar Shah's framework on virtual power plants and flexible interconnection

Contact Information:
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Solen Works
mike@solenworks.com
www.solenworks.com

To: Maine Department of Energy Resources at doer@maine.gov
From: Maine Labor Climate Council
Re: Thermal Energy Network RFI

Thank you for the opportunity to provide comments on the RFI to inform the potential creation of a thermal energy networks program for Maine.

Maine Labor Climate Council (MLCC) is a coalition of labor organizations advocating for a pro-worker, pro-climate agenda in Maine. Our mission is to advocate for a clean energy economy at the scale climate science demands, create good union jobs and support more equitable communities. Our coalition's affiliated unions represent thousands of working Mainers who are the best trained and skilled to build the state's new clean-energy economy from the ground up. MLCC includes leadership from labor organizations representing the range of skilled trades required to construct, operate, and maintain geothermal systems and thermal energy networks.

MLCC response to RFI:

1) Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country.

Thermal Energy Networks (TENs) are one of the lowest-emission and most efficient technologies available to heat and cool buildings.[1] They allow for the exchange of heat with a number of sources, such as lakes and rivers, energy intensive buildings like data centers, wastewater systems, or even the stable temperature of the earth, and can be designed with backup systems to remain reliable even amid a power outage. TENs can operate in residential, commercial, and industrial contexts for building heating and cooling purposes, and community and utility-scale pilots typically take advantage of mixed-use environments to efficiently balance diverse heating and cooling needs across users connected to the system. At scale, thermal energy networks can efficiently serve an entire neighborhood's heating and cooling needs without the use of fossil fuels.

To date, twelve states have passed significant legislation that take steps toward advancing TENs, with several more introduced or pending. This includes eight states that have passed legislation authorizing or requiring IOUs to develop thermal energy network (UTENs) pilots. Currently at least 20 utility thermal energy network pilot projects are operating or under development across five states.[2] These pilots in development serve a wide range of building types with various system configurations including systems serving mixed-used neighborhoods, public housing complexes, and projects that integrate data centers to beneficially utilize waste

[1] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[2] States with utility TENs pilots under development include New York, Massachusetts, Minnesota, Colorado, and Maryland.

heat. In addition to utility projects, several states are also advancing thermal energy networks as a key strategy for efficiently decarbonizing large state facilities. For example, New York State has directed the New York Power Authority to develop “Decarbonization Action Plans” for the fifteen highest emitting state-owned facilities in New York State, and in FY2025 has enacted a budget that includes at least $200 million for the most shovel-ready thermal energy network projects at these facilities.[3]

In addition to being highly efficient and facilitating the decarbonization of buildings at a neighborhood-scale, TENs also have significant high-road and union job creation potential. Because of the similarities between TENs and natural gas distribution infrastructure, these systems require the same skills of the highly trained workforce currently employed in the construction, operation, and maintenance of the gas system. Thermal energy networks can be constructed most safely, efficiently, and cost-effective by leveraging this existing trained workforce and ensuring strong labor standards for thermal energy network construction and operation. Maine’s clean energy and workforce transition must ensure an abundance of high-quality clean energy positions. In order to protect workers from a loss in living standard, and to retain and grow a skilled clean energy workforce necessary to meet future labor demand, new clean energy jobs must provide the same high-quality employment and benefits for workers as those experienced by the existing unionized energy workforce. Low-road clean energy jobs hurt workers, working families, and communities—they also lead to low-quality installations which hinder the potential success of the industry. One recent example of a low-road installer hindering current Maine policy is Pine Tree Solar, a company in Hermon, ME, that has been sued more than a dozen times since June 2023 for issues such as not completing work or failing to refund money.[4] Their bad actions slowed Maine’s statutorily mandated attempt to decarbonize. Another example is the cable company subcontractor who died while installing fiber-optic cable to aid Maine’s policy goal of connecting every Mainer to high-speed internet.[5] This not only slowed Maine’s attempt to meet its policy goal, much more importantly a worker lost their life. Successful thermal energy network deployment with strong labor standards will not only leverage the existing skilled utility workforce, but can also be a major driver of high-quality clean energy jobs in the buildings sector.

3) Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;

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[3] New York’s $4.2 billion Environmental Bond Act, passed in 2022, provides funding for state agencies, local governments, and other partners to adapt to climate change, improve resiliency, and create green jobs. As part of this initiative, the Governor announced $150 million in grants to decarbonize New York State’s public college campuses, including through the installation of TENs. Press Release, Governor Hochul Announces $150 Million Investments in Clean Water, Clean Air and Green Jobs Environmental Bond Act Funding to SUNY and CUNY Campuses, N.Y.S. (Feb. 12, 2025), https://www.governor.ny.gov/news/governor-hochul-announces-150-million-investments-clean-water-clean-air-and-green-jobs?utm_source=chatgpt.com.

[4] https://www.bangordailynews.com/2025/10/06/bangor/bangor-police-courts/pine-tree-solar-sued-again/

[5] https://www.live5news.com/2023/01/18/subcontractor-dies-after-fall-bucket-lift-police-say/

A significant challenge for thermal energy network development is scaling utility systems, without placing an undue burden on the broader ratebase to cover the upfront costs of these projects. One area of opportunity is developing utility programs and new financing mechanisms that enable cost-sharing between the system customers and the utility, particularly for behind-the-meter upgrades. For example, a significant portion of Eversource's Framingham, Massachusetts pilot project costs resulted from covering all behind-the-meter construction, including appliance installation, but also necessary electrical upgrades and abatement of environmental hazards such as mold and asbestos.[6] In contrast is National Grid's pilot under development in Boston, Massachusetts which will serve several Boston Housing Authority (BHA) buildings in the Dorchester neighborhood. While National Grid will construct, own and operate a horizontal distribution loop and thermal borefield to serve the buildings, BHA will fund and conduct all behind-the-meter work, such as appliance installations, weatherization, and other upgrades of their buildings necessary to connect to the thermal energy network as part of their broader decarbonization mandate. Through this cost-sharing model, BHA can invest in the most clean and efficient heating and cooling system for their residents, and National Grid ratepayers will not be on the hook for 100% of project costs.

While programs that can braid together a wide range of funding sources– including tax credits, rebates, and low-income weatherization assistance programs – to fund needed building improvements are critical, state thermal energy network programs can also prioritize utility projects that allow for these kinds of cost-sharing with customers through some of the following strategies:

- *Authorizing utility pilots with public customers:* States may authorize or require rate-based utility pilots where utilities own and operate the front-of-meter infrastructure, while public building owners may pay the costs of behind-the-meter improvements necessary to electrify their heating and cooling and interconnect their buildings with the utility systems as in case of the National Grid pilot in Boston.
- *Mandating utility pilots in public buildings:* In establishing mandatory utility TENs pilot programs, states may also specify customer types, including the requirement that a minimum number of pilots proposed by each utility serve public building customers. This can provide the same cost-sharing benefits as the previous model, while ensuring that utilities pursue these public--private partnerships.
- *Utility-owned TENs paid for exclusively by large campus customers:* Some states, including Massachusetts[7], are also exploring new models of utility TENs ownership where a utility owned and operated TEN could serve a single large campus customer, which would pay the utility back for all system costs over time. This could, for example, increase access to and lower upfront costs for TENs for colleges and universities by allowing them to pay for these systems over time, while limiting the impact of utility

[6] Building Decarbonization Coalition. "Case Study: Framingham, Massachusetts." https://buildingdecarb.org/resource/case-study-framingham-massachusetts
[7] Massachusetts introduced 2025 H4144 "Energy Affordability, Independence & Innovation Act."

TENs development on other ratepayers, who would not bear the costs of these systems serving large campus customers.

- *Establishing broadly available financing for residential and small commercial customers to pay back behind-the-meter improvements as part of a TEN overtime on their utility bill:* Some states are also exploring utility-financed upgrades, including a model known as "Inclusive Utility Investment", which allows individual customers to pay back energy efficiency and other upgrades over time on their utility bills from energy savings.[8] This model could increase access to residential upgrades, while minimizing the impact of UTENs on the broader rate base.

Finally, utilization of the incumbent utility workforce and enforcement of strong labor standards are also essential to gain cost efficiencies for thermal energy network construction, operation, and maintenance. Proper installation of heat pumps and other energy efficiency improvements is essential to ensure functional performance and that these systems deliver on their efficiency and energy savings benefits over the full lifetime of the equipment.[9] The existing utility workforce is also best equipped to safely and efficiently deliver utility-scale TENs infrastructure, which requires many of the same skills such as excavation, drilling, pipelaying, pipe fusing and pipefitting. By establishing strong labor standards for thermal energy network development, Maine can protect consumers and ensure properly operating and cost-efficient systems.

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

Thermal Energy Networks (TENs) are one of the cleanest and most efficient technologies available to heat and cool buildings[10] and investing in electrification through geothermal heat pumps can produce significant energy demand and cost savings. According to the U.S. Department of Energy, geothermal systems can reduce energy consumption by approximately 25% to 50% compared to air source heat pump systems. Geothermal heat pumps reach high efficiencies (300%-600%) on the coldest of winter nights.[11] A 2023 report from Oak Ridge National Lab also concluded that mass deployment of geothermal heat pumps across the US would reduce transmission expansion requirements 33-38%, an amount equating to roughly 24,500 miles of avoided transmission.[12] Transmission is one of the primary drivers of energy

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[8] Energy Star. "Inclusive Utility Investment."
[9] Pacific Northwest National Laboratory, DOE Building Technologies Office and Earth Advantage. "Energy Skilled: Preparing the Workforce for a Clean Energy Future"
[10] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[11] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[12] Oak Ridge National Laboratory. November 2023. "Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States."

costs in Maine – in New England, annual transmission charges have grown to $3.3 billion, from $869 million in 2008[13] and in January Central Maine Power Co. customers began paying 7% more in their monthly bills Jan. 1 to help fund $3.3 billion of upgrades to transmission lines.[14] Investing in highly efficient building decarbonization through geothermal heat pumps and thermal energy networks can significantly reduce peak demand and associated expensive grid build-out.

6) The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals;

Across the country buildings are responsible for nearly 31% of greenhouse gas emissions (GHG) when including electricity usage.[15] Reducing GHG emissions from buildings is an essential component in helping to meet Maine's statutory emissions reduction goals, and TENs are perfectly suited to help meet these goals.

Maine's state goals for emissions reductions are enshrined in law[16] as follows:

1. By 2030, the State shall reduce gross annual greenhouse gas emissions to at least 45% below the 1990 gross annual greenhouse gas emissions level.
2. By 2040, the gross annual greenhouse gas emissions level must be on an annual trajectory sufficient to achieve the 2050 annual emission level goal.
3. By 2050, the State shall reduce gross annual greenhouse gas emissions to at least 80% below the 1990 gross annual greenhouse gas emissions level.

In addition, by 2045, net annual greenhouse gas emissions may not exceed zero metric tons.

Maine law also requires the prioritization of emissions reductions by sectors. In particular, Maine law prioritizes those sectors that are the most significant sources of greenhouse gas emissions as identified by the United States Energy Information Administration, and in the Maine Department of Environmental Protection's (DEP) biennial reports.[17]

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[13] UtilityDive. November 19, 2024."Not just a 'boondoggle': State regulators, industrial companies push for cost effective transmission"

[14] Portland Press Herald. January 7, 2025. "Maine electricity bills increased again this month."

[15] U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022. https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.

[16] Maine Revised Statutes, title 38, § 576 (2023). Retrieved from https://legislature.maine.gov/statutes/38/title38sec576.html; see also Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals (2024) (released June 10, 2024), available at https://www1.maine.gov/dep/news/news.html?id=12801571 (last visited Oct. 2, 2025).

[17] Maine Revised Statutes, title 38, § 576-A (2023). Retrieved from https://legislature.maine.gov/statutes/38/title38sec576-A.html.

Although Maine has recently made progress towards its greenhouse gas emissions reduction goals, according to the DEP's latest report, the residential and commercial sectors remain significant contributors to Maine's gross GHG emissions.[18] In both the commercial and residential sectors, space heating and cooling are commonly responsible for contributions to Maine's greenhouse gas emissions, mostly as a result of delivered fuels such as home heating oil.[19] Using TENs would help Maine meet our established goals for emissions reductions because they are the most climate-friendly, highest efficiency option for space heating and cooling in residential and commercial settings, and TENs projects can create high-quality union jobs.

Across Maine, TENs are likely to be the best option for lowering emissions in both commercial and residential space heating and cooling. Fundamentally, TENs will often be the most efficient option available for both energy savings and functionality, if properly installed.[20] This higher efficiency, along with their direct applicability to some of the most difficult to decarbonize sectors in Maine – residential and commercial space heating and cooling – means TENs must be part of Maine's plan to meet its goals. Maine must include TENs as part of its plan to meet its emissions goals, and we should also ensure proper installation of TENs by requiring the use of well-trained, highly skilled workers working under robust safety and labor standards. We will only meet our state's climate and clean energy goals if TENs systems are built properly with a well-trained, experienced and qualified workforce. And if we do, TENs present an enormous opportunity to help Maine achieve our GHG emissions goals, in part because

7) Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;

Maine should ensure widely-accepted, reasonable and appropriately high labor standards on TENs to establish a pipeline of work for a trained workforce and ensure workers are not left behind

TENs represent an exciting opportunity in Maine, not only for the emissions reductions they represent, but also for the creation of high-quality union careers for Maine's local workforce. As Maine develops TENs for our public buildings, through the state's public utilities, or across the state writ large, it is imperative that strong labor standards are applied to these important projects.

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[18] Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals Appendix A, Table A4..
[19] Maine Dep't of Envtl. Protection, Tenth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals, Appendix C.
[20] Pacific Northwest National Laboratory, DOE Building Technologies Office and Earth Advantage. "Energy Skilled: Preparing the Workforce for a Clean Energy Future"

Strong labor standards would ensure that TENs projects create quality jobs for Mainers, and also ensure that, as with incumbent workers in the unionized gas industry, Mainers get trained with the skills necessary for proper installation. At base level and in an attempt to avoid potentially dangerous corner-cutting when it comes to the cost and quality of labor, the construction of TENs projects across Maine should meet or exceed prevailing wage rates and benefits. Further, Maine must incorporate certified pre-apprenticeship and registered apprenticeship utilization standards to ensure that we create a robust and sustainable pipeline of well-trained, highly-skilled local workers available for TENs construction. These standards would also ensure projects qualify for the IRA's Investment Tax Credit, which applies to qualifying geothermal projects and survived the most recent changes made in Public Law 119-21 in July 2025[21]. Maine should also apply licensing and certified contractor requirements for both behind-the-meter and front-of-meter work. Given the complexity and sensitivity of subsurface work in existing utility rights-of-way, TENs work in Maine should include Operator Qualification standards similar to and as required in the natural gas industry, as well as explore the applicability of related standards and/or licensing for equipment operators in the industry.

As the demand for TENs increase across the country, the demand for the highly skilled workers that construct TENs projects will also increase.[22] Thus it is all the more important that Maine require the use of certified pre-apprenticeship programs, registered apprenticeship programs and licensing standards in the construction and operations of TENs. These standards would establish a pipeline of work – a necessary precondition for training programs to invest in skilling up workers who would otherwise not be available to do this work. Without such standards, Maine may end up with a shortage of trained workers able to do drilling, pipelaying, and looping, electrical work, HVAC installation and servicing – which could end up costing Mainers in the long run. In addition, Maine should require that these projects – which often require the excavation or use of publicly owned land — pay the prevailing wage and benefits rate.

It is important to note the installation and maintenance of TENs require similar skill sets to those used by unionized trades employed in the construction, maintenance, and operation of the existing gas distribution system. High labor standards would ensure that these workers are positioned to be part of the workforce for TENs projects. Without high labor standards on TENs projects Maine risks putting these workers into a race to the bottom, or even leaving them behind. Instead, through the application of high labor standards, we can ensure Maine workers continue to have family-sustaining wages and benefits, high safety standards and union careers as they build out TENs projects across Maine.[23]

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[21] Text - H.R.1 - 119th Congress (2025-2026): One Big Beautiful Bill Act | Congress.gov | Library of Congress

[22] Home Energy Efficiency Team. Workforce Transition. https://www.heet.org/workforce-transition.

[23] Understanding Thermal Energy Networks. Cornell ILR, 2024, https://www.ilr.cornell.edu/sites/default/files-d8/2024-12/understanding-thermal-energy-networks.pdf.

In addition to prevailing wage and apprenticeship utilization requirements, it is essential that labor standards baked into the framework for TENs in Maine ensure a just and equitable transition and continuity of job quality for incumbent workers in the natural gas industry who will be directly impacted by the state's building decarbonization policies. This should apply to both workers who currently construct gas systems as well as utility workers who operate and maintain those systems, and is essential for continuity of job quality and retaining a highly skilled workforce. New York's UTENs legislation has some of the strongest and most effective standards to ensure that proposers of pilot TENs projects ensure that the incumbent gas utility workforce is highly prioritized for any TENs construction, operation or maintenance.[24]

8) Funding opportunities and cost recovery mechanisms, including, but not limited to: a) Leveraging applicable tax credits and other federal assistance; b) Funding from the New England Heat Pump Accelerator; c) The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and d) Rebates for heat pumps through the Efficiency Maine Trust;

According to the U.S. Department of Energy, although the upfront cost of installing a geothermal heat pump system is more expensive than installing an air source system of the same heating and cooling capacity, the additional cost can typically be recouped in energy savings in just 5 to 10 years.[25] These systems also tend to last longer and require less maintenance than air source heat pumps.[26]

In addition to their inherent cost-saving potential due to high efficiencies and low maintenance costs, commercial geothermal heat pumps and thermal energy networks are the only space heating and cooling technology that continue to be eligible for federal clean energy tax credits, and utilities and public entities can still access these credits through 2035 to cover a significant portion of TENs project costs. These credits are enhanced by meeting prevailing wage, apprenticeship, domestic content and energy community requirements, and some states have mandated that utilities maximize federal funding opportunities in development TENs pilots in order to limit potential impacts to ratepayers.[27]

Residential geothermal heat pump installations as part of TENs can also leverage available rebates through Efficiency Maine Trust. Maine could also require utilities to establish new accessible financing mechanisms, such as "Inclusive Utility Investment" programs that could facilitate affordable energy efficiency upgrades and heat pump installation. These programs

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[24] https://www.nysenate.gov/legislation/bills/2021/S9422
[25] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[26] U.S. Department of Energy. Energy Efficiency & Renewable Energy: Guide to Geothermal Heat Pumps.
[27] Maryland HB 397 "WARMTH Act." Enacted in 2024.

can also facilitate more effective and equitable cost-sharing between individual customers connected to a TEN and the broader rate base when developing TENs.[28]

Finally, Maine can leverage additional low-cost public financing to support TENs development, particularly projects serving public entities such as state facilities, schools, and public housing developments. Several states have established grant and low-interest loan programs to facilitate TENs development through their state green banks, power authorities, and energy offices including Illinois[29], New York[30], Colorado[31], and Connecticut[32].

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

- **Affordability for ratepayers**: Thermal energy networks can provide clean and affordable energy. Ground source heat pumps are highly efficient requiring less electricity use than other traditional electric technologies while also lowering impacts to the grid. An Oak Ridge National Laboratory study found that the deployment of large-scale ground source heat pumps (which could be connected to a thermal energy network) required less grid infrastructure, and the cost saved from spending on grid infrastructure upgrades could reduce the cost of power for all grid consumers.[33]
- **TENs on new residential construction:** Thermal energy networks on new construction can make housing development more affordable. TENs in new construction are more cost-effective compared to retrofitting existing building stock, which would require additional energy efficiency and weatherization retrofits to install the proper heat pump.
- **Utility driven TENs with public customer**: Cost-sharing models between a utility and public customers can help alleviate ratepayers from covering all upfront costs associated with a TENs project. Through a cost-sharing model, public customers can cover project costs associated with the behind-the-meter work while the utility covers project costs associated with the front-of-the-meter, which would most likely be rate-based. These types of partnerships can make TENs projects on residential buildings more feasible and more affordable. There are some examples of this model in New York and Massachusetts. Through New York's utility TENs pilot program ConEd is working to integrate New York City Housing Authority properties into a TEN. Another example of this model and partnership with public customers includes the National Grid, a utility in Boston, and the Boston Housing Authority.

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[28] Energy Star. "Inclusive Utility Investment."
[29] Illinois Finance Authority/Climate Bank. Climate Pollution Reduction Grant Community Geothermal Planning + Pilots program.
[30] NYSERDA. Large Scale Thermal Program.
[31] Colorado Energy Office. Geothermal Energy Grant Program.
[32] Connecticut. Thermal Energy Network Grant and Loan Program.
[33] Oak Ridge National Laboratory. Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States. November 2023. Pg. xii.

SIERRA CLUB
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To: Maine Department of Energy Resources
From: Sierra Club Maine
Date: 10/17/2025
Re: Request for Information Regarding Thermal Energy Networks Pursuant to Resolves 2025, ch. 67 (LD 1619)

We are pleased to be able to respond to the *Request for Information Regarding Thermal Energy Networks Pursuant to Resolves 2025, ch. 67 (LD 1619)*.

We write on behalf of the Sierra Club Maine, representing over 20,000 supporters and members in Maine and millions nationwide. Founded in 1892, Sierra Club is one of our nation's oldest and largest environmental organizations, and we're working diligently to combat climate change and promote a just and sustainable energy future for all people.

Our comments are made alongside the Portland Climate Action Team (PCAT) as they have been examining the technology for several public buildings in Portland.

Thermal Energy Networks (TENs) is a recent phrase to designate a mature technology based on a fairly long history of use, often previously called district heating. The newest systems, termed 5th generation, employ highly efficient ground source heat pumps to extract heat or cold from a continuous loop of circulating fluid at ambient ground temperature. This current realization of the technology promises both heating and cooling, lower costs for installation and operation, substantial reductions in GHG emissions associated with energy usage, and simpler, quieter, cleaner zones where it is applied. We believe it will be especially attractive for new developments – residential, commercial, and industrial; and it should become the technology of choice in the future for supplying space heating/cooling and heat/cold for some commercial applications. TENs are a technology that can significantly help Maine reach its climate goals in Maine Can't Wait and its electrification goals in Pathways to 2040.

Our responses to this RFI are grouped below according to the eleven themes given in the Department of Energy Resources (DOER) document.

1) *Any relevant available research, framework, pilot projects, system configurations and other information on the total cost, cost savings and efficiencies realized in thermal energy networks across the country;*

Many others may submit information on specific projects in the US, but the US is rather slow to adopt the latest TENs technology as well as its previous formulations as district heating using a central heating plant. Today's TENs potential exists due to improved efficiencies in heat pumps and decreasing drilling costs. TENs is a technology that applies in climate zones from Texas to Minnesota and has already been realized to some degree in 20 states. Outside the US, TENs has gained a significant foothold in some countries, and China, India, Germany, France, and the UK are predicted to exceed the US in the rate of investment in TENs facilities. Canada currently has about 3% of its building stock heated by TENs facilities and is focusing on significantly raising that figure. With the need to reduce fossil-fuel consumption, these countries are rushing to implement electrified, energy-efficient technologies to enable the energy transition.

The energy cost savings of TENs is well known. EnergySage reports that ground source heat pumps (GSHPs) can achieve 600% efficiency while air source heat pumps (ASHPs) can achieve only up to 400%. A study by Applied Economics Clinic of Massachusetts homes concluded that TENs heating is by far the most economical heating option, with life-time costs less than ASHP heating and less than natural-gas heating in 2020, projected to become up to three times less by 2050. While the efficiency of ASHPs are affected by outdoor ambient temperature and can plummet to one-half that at 60°F as temperatures dip to 0°F and below, the efficiency of GSHPs is mostly unaffected by variation in temperature.

We know that widespread adoption of ASHPs will significantly reduce fossil-fuel use while saving energy costs, but this will create a challenging nighttime demand curve in winter for electricity. Synapse Energy Economics did a study on partially substituting TENs for air-source heat pumps, finding that the winter demand curve could be greatly shaved and that annual benefits measured in billions could be achieved across the New England states.

2) *The feasibility and applicability of thermal energy networks for residential, commercial and industrial sectors in the State, which may include information related to:*

a) Geophysical considerations;

b) Compatibility with incumbent air source heat pumps and other heating, ventilating and airconditioning systems, in particular describing the process of retrofitting existing buildings onto a thermal energy network;

c) Permitting and right-of-way considerations;
d) Constraints around geographic density; and
e) Other considerations that demonstrate the total building heating and cooling load potential of thermal energy networks;

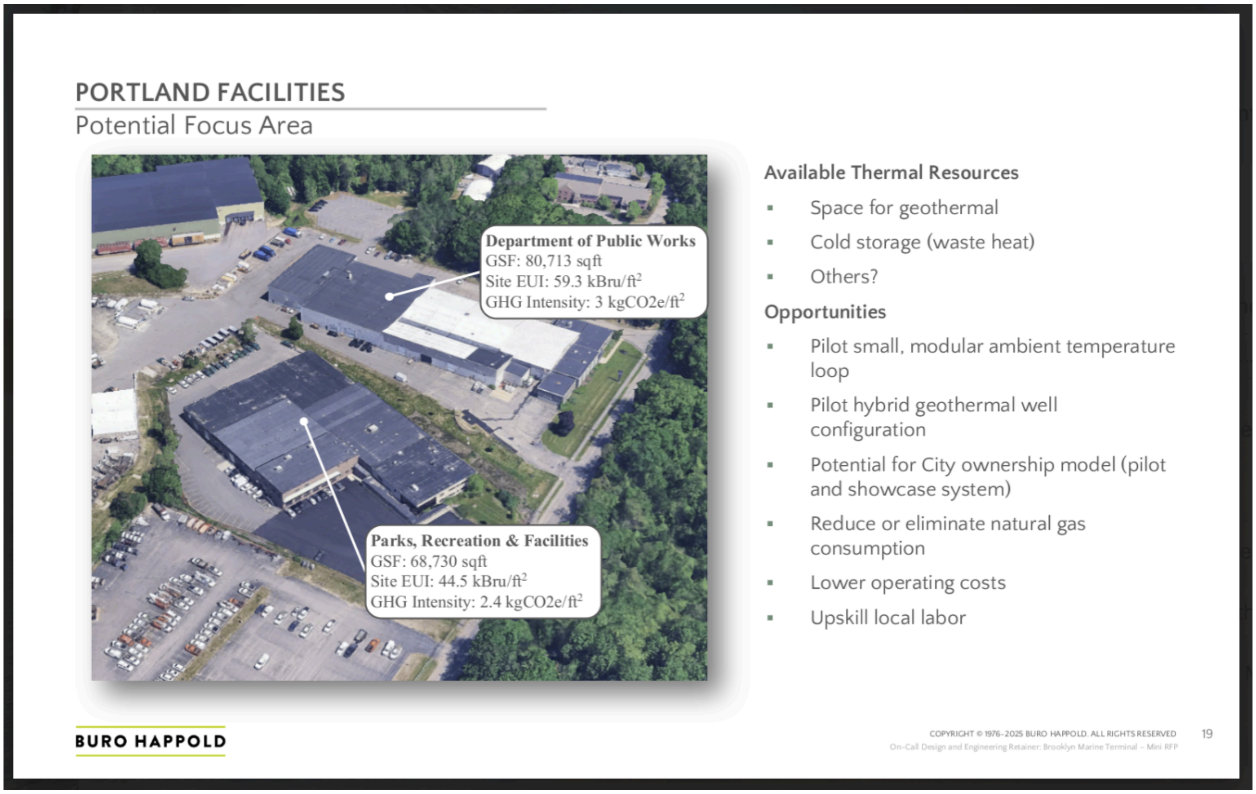
(a) Although TENs may be most easily adopted by geologic areas with fairly thick soil layers and minor to no outcropping, it will be suitable in Maine wherever gas utility pipelines could conceivably be placed because TENs loops can be placed at depths comparable to gas pipelines. According to Energy Information Administration (EIA) data, there are nearly 50,000 natural-gas customers in Maine, with roughly ¾ of those being residential. If the gas utilities can develop their network to such a large customer base, it seems reasonable that TENs would be possible in those same areas. Furthermore, much of the state with favorable geology is not served at all by natural-gas utilities, but those areas can still be suitable for the isolated nature of TENs.

(c) Permitting and ROW issues and procedures will be very similar to those managed by the electric, natural-gas, and water utilities. Staff personnel in cities and towns are already familiar with these issues and with the procedures to acquire permits and ROWs, and workers for the private sphere developing TENs could be drawn from the pool that are already skilled in handling these issues.

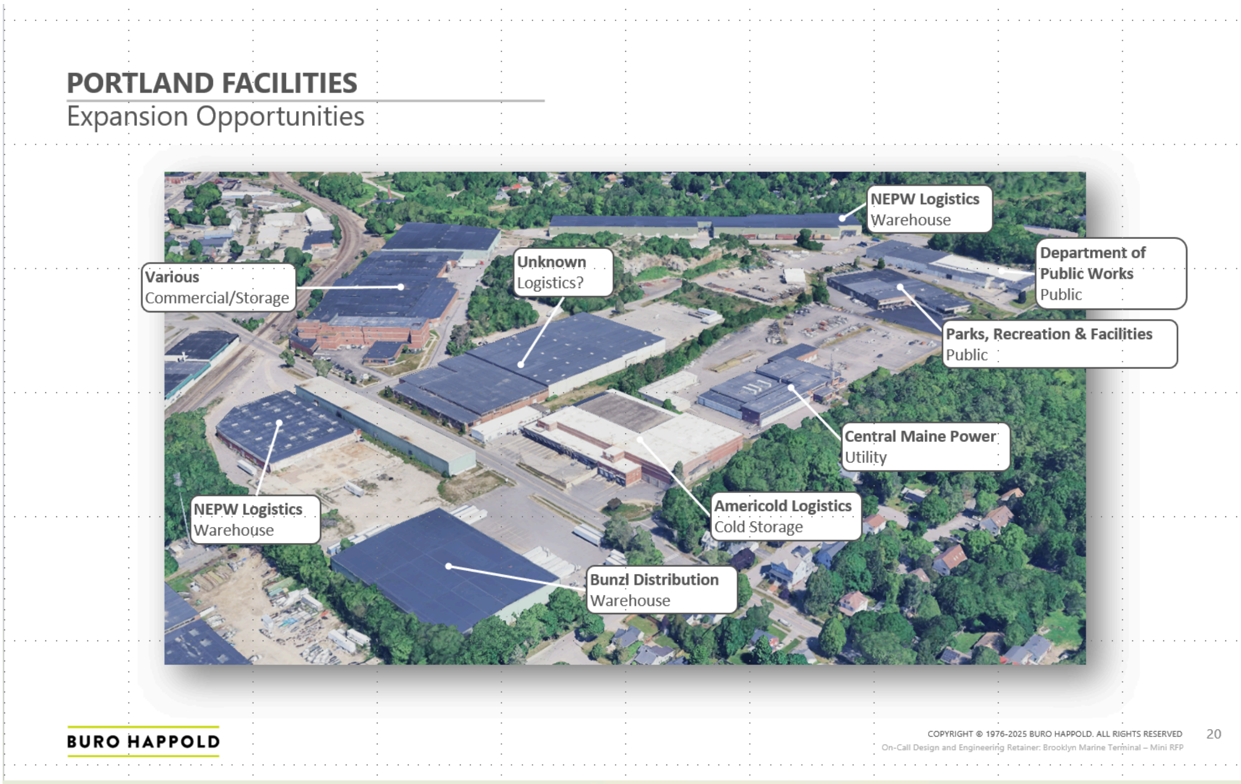
3) Considerations for facilitating potential thermal energy network pilot projects, including costs, ownership structures, utility customer data needs, rate designs, and cost recovery mechanisms;

Given the urgency of the climate crisis, the relative simplicity of TENs, its proven positive effects, and the already successful implementation of this technology at many sites already, we urge moving directly to a full program for TENs in the state of Maine. To meet that goal, we recommend that DOER and PUC personnel, and those of other appropriate agencies, attend the Geothermal Network Regulator Forums sponsored by HEET. Eight states already have set up the regulatory framework for TENs, and these policies will be a rich resource for determining Maine's policy.

If on the other hand a pilot project is the preferred next step, PCAT has identified two City of Portland buildings that the Portland Sustainability Director is considering for a TENs application. This may also be developed in conjunction with a roof mounted solar array on the two buildings that could provide 100% renewable energy to the GSHP system.



The two City of Portland Public Works Buildings on Canco Road in Portland are also adjacent to several other commercial buildings that could be connected to an expanded TENs in the future. Interestingly, one of the buildings is owned by CMP. CMPs involvement with demonstrating the TENs application may be an important aspect of marketing the technology. The expanded network of commercial buildings is shown below.



4) Life-cycle costs and benefits of commercially available or emerging thermal energy network technologies, including comparisons to incumbent heating and cooling technologies appropriate for the Maine climate;

An important aspect of considering life cycle costs for TENs that utilize geo-exchange and GSHPs is the potential tax credit that is still available from the federal government for 'geothermal' systems. Although the tax credit for residential properties is being phased out by 2026, the credit for commercial properties will still be in effect under the 'One Big Beautiful Bill' passed in July 2025. See GeoExchange Update on U.S. Budget Reconciliation Bill, July 3, 2025:

> "On the commercial side, the Sec. 48 Investment Tax Credit was untouched. There is a 30% credit for commercial projects until 2033 when the credit drops to 26%. It is 22% in 2034 and zeroes out in 2035. The domestic content and energy communities bonus credits are still available as is direct pay and transferability."

The DOER should consider the tax credits which are still available for GSHPs as an extra incentive over the application of ASHPs.

5) Potential electric grid impacts, such as smoothing winter and summer peaks and lowering system costs by avoiding or deferring investments in additional electrical generation, transmission and distribution infrastructure;

Because GSHPs especially outperform ASHPs in cold winter months, there would be a decrease in anticipated electrical load when GSHPs were used instead of ASHPs. Thus, each new TENs development that avoided a comparable development with ASHPs would decrease the future electrical load.

6) The suitability of thermal energy network technology for helping to meet the State's statutory emissions reduction goals;

TENs technology is based on electrical energy and is therefore quite suitable in pursuit of Maine's climate goals (Maine Can't Wait). By far the most efficient and the least energy-intensive method of cooling and heating (except for passive means), TENs can be a prime element in achieving Maine's climate goals.

7) Labor and workforce needs associated with developing thermal energy networks in the State, including consideration of job quality, supplying a skilled and ready workforce, licensing and registered apprenticeship and certified pre-apprenticeship programs, and other considerations;

TENs development requires few special skills that don't already exist in the Maine workforce. It will draw heavily from the pool of workers who have already installed hundreds of thousands of heat pumps in Maine, from the pool of potable-water well drillers, and from the pool of workers involved in continually undergrounding water, natural gas, and electrical utility lines throughout the state. TENs may offer one of the easiest transitions for skilled and unskilled workers in Maine, providing just and equitable adaptations.

8) Funding opportunities and cost recovery mechanisms, including, but not limited to:

a) Leveraging applicable tax credits and other federal assistance;
b) Funding from the New England Heat Pump Accelerator;
c) The Thermal Energy Investment Program established in the Maine Revised Statutes, Title 35-A, section 10128; and
d) Rebates for heat pumps through the Efficiency Maine Trust;

(c)The Thermal Energy Investment Program administered by Efficiency Maine Trust provides loans for projects utilizing biomass to produce heat. An extension of that program to TENs under current legislation (35-A, §10128) may not be possible, but simple legislation could be enacted to enable that extension, or entirely new legislation may be needed to address the specifics of TENs.

9) The role thermal energy networks can play in increasing the affordability of housing, development and energy;

Although the residential tax credit for geothermal systems is expiring at the end of this year, there may now be a way to use the Commercial Credits still available through a recent exemption to IRS policy to provide TEN to residential customers through a leasing arrangement. We would like to work with the DOER to further this mode of operation.

10) Additional considerations including:
a) Technology alternatives or companion solutions (e.g., solar, storage, distributed energy resources, etc.) to thermal energy networks;
b) Lifetime and annual project cost-effectiveness, including assumptions, of thermal energy networks;
c) Explain the applicability, benefits, challenges and scalability of thermal energy networks to various geographic regions in Maine (e.g., urban, rural, remote, etc.);
d) Outline any considerations for new construction or retrofit projects adopting networked geothermal;
e) The safety, reliability, and resiliency of thermal energy networks during both normal operations and during outages or extreme weather;
f) Utility ownership, regulatory and cost allocation/recovery frameworks that may be applicable to thermal energy networks, including frameworks that currently exist in Maine law; and

(a) We assume that a TEN will be totally electrified. If grid-connected, there certainly will be service outages, and battery energy storage may then be a logical addition to the TEN. This storage then can be applied in a Virtual Power Plant (VPP) arrangement to both exchange energy with the grid. In this arrangement, it becomes just an enlarged version of home batteries in a VPP arrangement, capable of supplying regional grid services while protecting local services within the TEN during outages.

(f) We strongly favor an ownership model whereby the customers served by a TEN are able to own the TEN much like a rural electrical coop and then additionally benefit monetarily in whatever grid services are provided by the TEN. The TEN coop would initially start with one project and then extend itself for the next, and so on, gradually developing into a utility coop serving

TENs across the state. In this model, the TENs coop is distributed rather than being localized as rural electrical coops are. The distributed model spreads the risks to reasonable levels, combines identical functions into one department, and benefits from growth due to economies of scale.

11) Any additional information relevant to the scope of this RFI.

Summary

We recommend that the DOER create, in conjunction with other relevant Maine state agencies such as Efficiency Maine Trust, a meaningful program, based on responses to this RFI, for hastening the development of TENs throughout Maine. We firmly believe we are beyond the “pilot” program stage, given the success in other states and nations with TENs. Following the successful program that has brought hundreds of thousands of air-source heat pumps to Maine, this is a logical next step.