# HEET Kickstart – Deerfield Networked Geothermal Feasibility Study

## Technical Report

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21 August 2025

P02

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# Glossary

| Term | Definition |
|---|---|
| GHG | Greenhouse gas |
| $CO_2$ | Carbon dioxide |
| TEN | Thermal energy network |
| BGS | Below ground surface |
| WSHP | Water-source heat pump |
| ASHP | Air-source heat pump |
| GSHP | Ground-source heat pump |
| ccASHP | Cold climate air-source heat pump |
| COP | Coefficient of performance |
| NREL | National Renewable Energy Laboratory |
| IRA | Inflation Reduction Act |
| USGS | United States Geological Service |
| EUI | Energy use intensity |
| ROW | Right-of-way |
| ROI | Return on investment |

# 1 Executive Summary

Heating and cooling demand across the building sector is responsible for approximately one third of all energy consumption in Massachusetts.[1] Natural gas is currently the main fuel source that provides heating energy to residential buildings across the state. While air-source heat pumps are becoming increasingly popular solutions to electrify heating in Massachusetts and across the United States, there is a risk that rising electrical demand for heating will shift annual peak loads to the winter months – creating increased strain across an aging electrical grid. Networked geothermal is an emerging technology capable of mitigating this risk through lower energy consumption by increased heating and cooling efficiency and enabling the storage and sharing of thermal energy along a distribution network.

HEET, with support from the Massachusetts Clean Energy Center, created Kickstart Massachusetts, a project to fund feasibility studies to explore networked geothermal technology across the Commonwealth. Deerfield was one of the recipients of a grant to explore the feasibility of geothermal in their town. The town of Deerfield, Massachusetts engaged Buro Happold to complete a feasibility study to determine the viability of a networked geothermal system to serve a subset of their building stock. This project can serve as an example for other communities in western Massachusetts on how to address the challenges of heating electrification and transition away from natural gas.

To understand the viability of installing a geothermal network, a GIS-based assessment using key selection criteria was completed, including key infrastructure network obstructions, areas of biodiverse significance, building typologies, open spaces for the geothermal borefield, pump house siting, and demographic indicators. Across the town, three study areas were identified. The first iteration would include 25 buildings within the center of Deerfield, including Deerfield Town Hall, Deerfield Police Department, Tilton Library, and Deerfield Elementary. A key tenant in this first iteration is Berkshire Brewing Company – a local brewery whose waste heat could be captured at the source and injected into the network for building heating. The second iteration builds upon the first, and extends the loop northward to Frontier High School, South Deerfield Fire Department, South County Emergency Medical Services, and additional residential buildings. Finally, the third iteration would build upon the second, and extend further north to capture and integrate Tree House Brewing and Pelican Products which would provide additional waste heat resources to the network.

Community engagement was done to inform the public of the technology and gauge general interest. A survey was hosted by the town and included 29 responses. Public meetings about the study were held on July 30, 2024, July 31, 2024, and July 17, 2025 and were formatted as information sessions with time at the end for questions from the public. The survey and public information sessions yielded substantial public interest.

The results of the feasibility study show that despite technical feasibility, the current iterations are cost prohibitive and non-competitive with other alternatives. If a networked geothermal system were to be implemented in the town of Deerfield, it would need to include all of the single-family homes surrounding the three iterations in this study plus an additional population density that could include at least 200 additional residents which may include a cultural living center and an assisted living facility. Other alternatives to evaluate in the future may consider standalone ground source heat pumps for the school system including Deerfield Elementary and Frontier High School, installation of cold climate air source heat pumps for individual homes and businesses, or a geothermal network that has higher building diversity, total square footage, and waste heat availability.

[1] Clean Energy Group. "Massachusetts Renewable Heating and Cooling." https://www.cleanegroup.org/wp-content/uploads/Meister-MA-renewable-thermal-study.pdf

# 2 Introduction

## 2.1 Project Context and Motivation

Natural gas has long served as a significant part of Massachusetts' energy mix – accounting for 76.1% of generation capacity and 52% of the State's residential heating fuel.[2] While natural gas is a critical component of the state's fuel supply, it is also a key contributor of greenhouse gas (GHG) emissions. Along with the downstream emissions produced from combusting natural gas to produce heat or electricity, gas leaks along existing and often antiquated infrastructure can release methane – a GHG with more than 80 times more global warming potential than $CO_2$.

Scientific findings, economic realities, and policy initiatives across spatial scales are rapidly driving the case for electrification and broader decarbonization. To prepare for the energy transition, cities must consider pathways for implementing cost-effective solutions that can provide their residents with electrified, renewables-led heating and cooling energy at-scale while meeting their often-aggressive emissions targets. However, electrifying cities presents several challenges. The increased demand for electricity can strain existing grids, necessitating significant and costly infrastructure upgrades.[3] Additionally, the integration of renewable energy requires substantial investment and careful planning to ensure reliability and stability.[4] Urban areas also face logistical challenges, such as the need for extensive retrofitting of buildings and the installation of new electric vehicle charging stations.[5] Furthermore, equitable access to these new technologies must be ensured to avoid exacerbating social inequalities.[6]

Deerfield – a town of more than 5,000 residents – is a part of Franklin County, which has set a Regional Plan for Sustainable Development aiming to improve wide-ranging sustainability across its jurisdiction.[7] Currently Franklin County's carbon emissions per capita are the highest across Western Massachusetts and higher than the statewide average. While this is largely the result of high fossil fuel-consuming transportation use, the County has set sustainability goals including:

- Increasing energy efficiency of housing stock
- Increasing the quantity of locally-produced clean energy
- Reducing the use of fossil fuels

Given its rising population and increasing demand for clean energy, Deerfield needs a scalable, low-carbon technology capable of delivering heating and cooling to its building stock. Buro Happold is working with the town of Deerfield to understand the viability of a networked geothermal system to reduce heating and cooling energy demand for homes and commercial businesses. Utilizing geospatial mapping and thermal energy modelling, this study aims to identify the scale and configuration of geothermal network that could deliver resilient clean energy to a region of Deerfield.

## 2.2 Stakeholder Engagement Efforts

Stakeholder engagement efforts were completed by the town of Deerfield and included a public survey and public information sessions.

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[2] https://www.mass.gov/info-details/how-massachusetts-households-heat-their-homes
[3] https://www3.weforum.org/docs/WEF_Urban_electrification_and_energy_efficiency_2023.pdf
[4] https://news.climate.columbia.edu/2022/06/03/what-makes-electrifying-the-economy-so-challenging/
[5] https://www.weforum.org/agenda/2022/01/the-ev-revolution-obstacles-solutions/
[6] https://www.ifpenergiesnouvelles.com/article/smart-city-energy-challenges-facing-sustainable-cities
[7] Franklin County. "Sustainable Franklin County." https://deerfieldma.us/DocumentCenter/View/359/Sustainable-Franklin-County-Executive-Summary-PDF

Initial project meetings were conducted at Municipal Vulnerability Preparedness (MVP) Core Group and Energy Conservation Committee meetings on July 30 and 31, 2024 respectively. The project team presented a slideshow detailing the Feasibility study funded by the HEET Grant and background on what a networked geothermal entails. Pilot locations (Framingham and Lowel) were discussed.

On October 13, 2024, students from the University of Massachusetts Landscape Architecture & Regional Planning (UMass LARP) presented on landscape architecture interventions to assist with decarbonization and energy transition, including geothermal options.

At the conclusion of the study, a public information session was held on July 17, 2025 and included a presentation by Buro Happold with a question and answer period following the presentation.

The public survey was open from July 7 to 18 with an extension until 25 due to public interest. The survey included the following questions. Appendix A contains the survey results.

### 2.3 Report Structure

The objective of this report is to provide a summary of the results from the initial feasibility study for a potential networked geothermal project in Deerfield. The remainder of the report is structured as follows:

- Section 3 (Policy and Regulatory Review): This section includes a discussion of Massachusetts policy as well as applicable local and state permitting and regulatory requirements for networked geothermal system construction.
- Section 4 (Site Options): This section introduces the three options Deerfield has presented for potential networked geothermal configurations.
- Section 5 (Geothermal and Energy Balance Analysis): This section discusses the methodology utilized by Buro Happold to evaluate the geothermal potential of the sites.
- Section 6 (Site Feasibility Analysis): This section summarizes the feasibility of the sites including techno-economic analyses and the final conclusions of those studies.

# 3 Policy and Regulatory Review

## 3.1 Gas-to-Geo Transition

The “gas-to-geo” transition refers to the emerging and rapidly progressing movement of switching building energy systems away from natural gas and other fossil fuel-based systems to electrified, geothermal-based systems that utilize similar distribution infrastructure to a natural gas network.

In recent years, regional disaster and academic studies have highlighted the risks of natural gas to human health and well-being. Natural gas is primarily composed of methane – a greenhouse gas with over 80 times the global warming impact of $CO_2$. Natural gas infrastructure is susceptible to leaks and explosions, which has become a prominent issue in the state of Massachusetts. In the fall of 2018, inadequate maintenance and operational procedures of gas lines in the Merrimack Valley region resulted in a series of gas explosions displacing several hundred residents.[8] Academic studies have demonstrated that cooking indoors with a gas range can negatively impact indoor air quality and contribute to asthma.[9] Thus, finding a solution to eliminate the dependence on gas-based heating systems, all while avoiding utility bill increases for customers is a key pathway to achieving many of the state’s sustainability, health, and equity goals. To address these issues, increasing numbers of networked geothermal systems are being evaluated and implemented across Massachusetts – the first utility-owned system was recently commissioned by Eversource in 2024.

Networked geothermal systems are a type of thermal energy network (TEN) that transfers the natural thermal energy from the ground to a group of buildings to provide space heating, cooling, and, in some cases, domestic hot water heating. Because the subsurface temperature remains roughly constant year-round, these systems can deliver consistent “ambient” temperatures (~55 °F) to buildings for both heating and cooling without vulnerability to extreme air temperatures in the winter or summer months. As shown in Figure 3-1, these systems typically include a borefield of geothermal wells which can extend beyond 1,000 feet, into which a loop of pipework is installed and grouted into place. Water mixed with a small amount of glycol is circulated through the closed loop of pipe where it is passively warmed or cooled depending on the temperature gradient of the ground. The water is then pumped through the distribution network to individual buildings. Within the building, heat pumps utilize this constant temperature fluid to heat or cool the conditioned space.

[8] Mass.gov. “Merrimack Valley Incident Report.” https://www.mass.gov/doc/merrimack-valley-incident-report/download

[9] Kashtan, Y., et al. (2024). “Nitrogen dioxide exposure, health outcomes, and associated demographic disparities due to gas and propane combustion by U.S. stoves.” *Science Advances*.

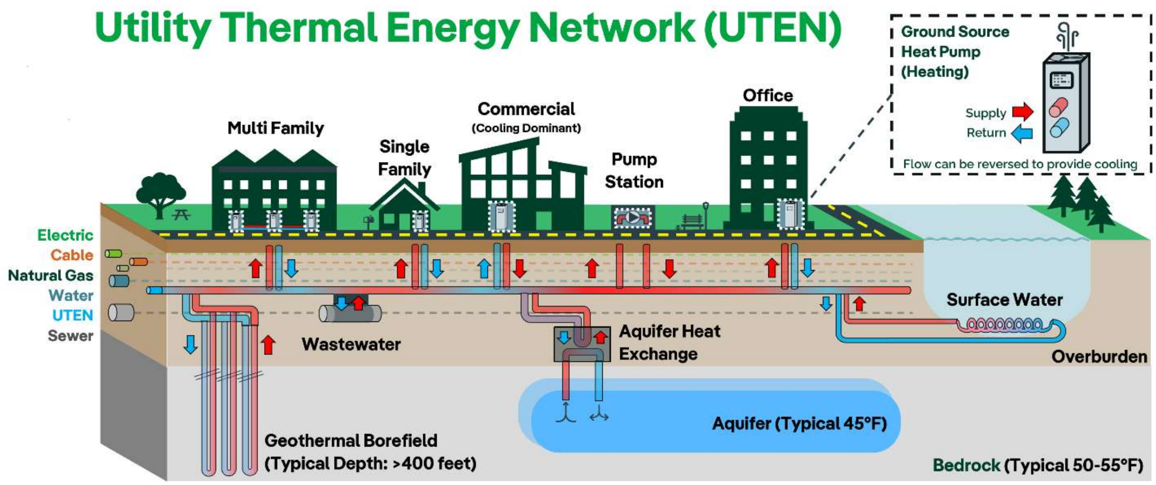


**Figure 3-1. Concept diagram of a networked geothermal system.[10]**

## 3.2 Legislation and Policy

In the last decade, geothermal networks have seen increasing legislative and policy-driven incentives associated with the development of clean energy technologies. Massachusetts has been a leader in supporting the development of new geothermal heating and cooling projects, both in response to the critical need to address a rapidly changing climate as well as the need to improve safety across the state's building stock.

In 2008, the State of Massachusetts passed the "Global Warming Solutions Act" – directing the Department of Energy Resources (DOER) and other state agencies to define economy-wide emissions reduction goals for the Commonwealth.[11] Updated most recently in 2021, the act has defined a legally-mandated state-wide goal of achieving a 50% reduction of greenhouse gas emissions compared to a 1990 baseline by 2030, a 75% reduction of greenhouse gas emissions compared to a 1990 baseline by 2040, and net-zero emissions by 2050. The foundational policy published by the commonwealth is known as the Massachusetts Clean Energy and Climate Plan for 2050,[12] which has been amended to set near-term targets for 2025 and 2030. In December 2023, the state issued the Massachusetts Department of Public Utilities (DPU) Order 20-80, which sets forth a new strategy to guide the evolution of the natural gas distribution industry toward clean energy and decarbonization.[13]

In 2020, Massachusetts passed "An Act For Utility Transition to Using Renewable Energy", a bill outlining the transition plan for the state to move from natural gas to clean energy in alignment with the state's mandated GHG targets.[14] As a result of this bill, the DPU approved the initial utility-led pilot projects in Massachusetts: one led by Eversource in Framingham and the other by National Grid in Lowell. The state has also passed subsequent legislation further incentivizing the piloting of these systems. Section 22 of "An Act Creating a Next Generation Roadmap for

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[10] New York State Electric and Gas. "Utility Thermal Energy Networks. Bringing Clean Energy Solutions to our Customers and Communities through Shared Thermal Resources. (2025)." https://www.nyseg.com/smartenergy/innovation/utility-thermal-energy-network

[11] Mass.gov. "Global Warming Solutions Act." https://www.mass.gov/info-details/global-warming-solutions-act-background

[12] Mass.gov. "Massachusetts Clean Energy and Climate Plan for 2050." https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050

[13] Mass.gov. "Department of Public Utilities Order 20-80." https://www.mass.gov/news/department-of-public-utilities-issues-order-20-80

[14] MA Legislature. Bill S.2302. https://malegislature.gov/Bills/190/S2302

Massachusetts Climate Policy," passed in 2021 and allows gas utilities to install demonstration projects for networked geothermal and sell thermal energy in addition to their electricity and gas services to customers.[15] Section 57 of Bill H.5060 – "An Act Driving Clean Energy and Offshore Wind" authorizes pipe replacement funds to be redirected toward renewable energy infrastructure and incentivizes gas companies to make long-term repairs rather than expensive replacement of old pipes.[16] As a part of this bill, the state's electric utilities were mandated to develop Electric Sector Modernization Plans to provide a path toward modernizing and decarbonizing the electric grid – specifically focused on adding system capacity, supporting electrification programs, and decarbonizing their existing portfolios. This act has resulted in planned substation expansions, new projects for installing distributed energy resources, and pledges by National Grid and Eversource to reach net zero emissions by 2050 and 2030 respectively.[17,18]

To further support the development of geothermal networks, there are extensive funding opportunities available through various state departments and federal agencies, as summarized in Table 3-1.

**Table 3-1. Funding opportunities for networked geothermal systems.**

| Name | Agency/Funder | Description | Funding Deadline |
|---|---|---|---|
| Clean Electricity Investment Tax Credit | Internal Revenue Service (Federal) | Reduces Federal income liability for a percentage of the cost of a qualified clean energy system installed during that year | Open until 2032 |
| IRC Section 25D: Residential Clean Energy Credit | Internal Revenue Service (Federal) | Tax credit based on amount invested in qualifying residential energy property | Open until 2032 |
| Modified Accelerated Cost-Recovery System (MACRS) | Internal Revenue Service (Federal) | Cost recovery through depreciation deductions. Applicable for geothermal heat pumps. | Open until 2032 |
| Energy-Efficient Commercial Buildings Tax Deduction (IRC Section 179D) | Internal Revenue Service (Federal) | Tax deduction for owners of commercial buildings who install systems to reduce total energy | Open until 2032 |

[15] MA Legislature. "An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy." https://malegislature.gov/Laws/SessionLaws/Acts/2021/Chapter8
[16] MA Legislature. Bill H.5060. https://malegislature.gov/Bills/192/H5060
[17] Eversource. "Electric Sector Modernization Plan." https://www.eversource.com/content/residential/about/sustainability/renewable-generation/electric-sector-modernization-plan
[18] National Grid. "Massachusetts Grid Modernization." https://www.nationalgridus.com/Our-Company/MA-Grid-Modernization

| | | | |
|---|---|---|---|
| High Efficiency Electric Home Rebate Act (HEEHRA) | U.S. Department of Energy (Federal) | Point of sale rebates for qualified electrification projects include heat pump HVAC and water heaters | No deadline |
| NSF 24-534: Civic Innovation Challenge (CIVIC) | National Science Foundation (Federal) | Funding program for projects that pilot community-driven, innovative, and actionable research-centered approaches and technologies that focus on strengthening the resilience of a community and its economy to climate- and associated environmentally-related instability and disasters | Ongoing (annual funding rounds) |
| DOE Energy Efficiency Conservation Block Grant (EECBG) Competitive Program | U.S. Department of Energy (Federal) | DOE administration of $440 million in formula and competitive EECBG program funding appropriated by IIJA | Next application round closes May 2025 |
| Mass Save Residential Rebates | Mass Save (State) | Rebates for energy efficiency technologies, including heat pumps and heat pump water heaters | No deadline |
| Alternative Energy Portfolio Standard[19] | Department of Energy Resources (State) | Incentives for homeowners and business to sell "Alternative Energy Certificates" in response to generating "naturally occurring temperature differences in ground, air or water" | No deadline |

### 3.3 Regulations and Permitting

In addition to the incentives and policies promoting the development of networked geothermal, local and state regulations and permits should be noted during the development of these systems. Table 3-2 summarizes the key information for permits required to facilitate construction of the civil infrastructure, geothermal borefield, and building-level upgrades in Deerfield.

[19] Mass.gov. "APS Renewable Thermal Qualifications." https://www.mass.gov/guides/aps-renewable-thermal-statement-of-qualification-application

The Deerfield Planning board meets monthly and is the designated Stormwater Authority, should the project achieve that threshold through a borefield. Site Plan Review would be required under section 5413 as a land development activity. An applicant would be able to simultaneously apply for both permits.

**Table 3-2. Key permitting requirements for networked geothermal construction and installation.**

| | | |
|---|---|---|
| Planning Board | | |
| Type of Permit/Inspection | Fee | Conditions |
| Stormwater Permit | $150 | *Review from Planning Board |
| Site Plan Review | $300 | *Review from Planning Board |
| *Site Plan Review required per (5413). Grading, clearing, or other land development activity EXCEPT for the following: landscaping on a lot with an existing dwelling, clearing necessary for percolation and other site tests, or work in conjunction with an approved subdivision plan or earth removal permit.* | | |
| Building | | |
| Type of Permit/Inspection | Fee | Conditions |
| Mechanical | | |
| Trench - Residential or Commercial | $50 | |
| Gas | | |
| Type of Permit/Inspection | Fee | Conditions |
| Residential Remodeling | $75 | |
| | $15 | Additional fixtures/appliance |
| Residential Water Heater Replacement | $100 | Gas Water Heaters |
| | $30 | Each additional fixture/appliance |
| Commercial (under 5,000 sq ft) | $150 | Covers each permit with 1 fixture/appliance |
| | $15 | Each additional fixture/appliance |
| Plumbing | | |
| Type of Permit/Inspection | Fee | Conditions |
| Residential Remodeling | $75 | |
| | $15 | Additional fixtures/appliance |
| Residential Water Heater Replacement | $100 | Electric Water Heaters |
| | $30 | Each additional inspection |

| | | |
|---|---|---|
| Commercial (under 5,000 sq ft) | $200 | Covers each permit with 1 fixture/appliance |
| | $15 | Each additional fixture/appliance |
| Commercial (over 5,000 sq ft) | $350 | Covers each permit with 1 fixture/appliance |
| | $15 | Each additional fixture/appliance |
| Commercial Water Heater Replacement | $75 | Per fixture/appliance |
| All Other Work (Residential OR Commercial) | $75 | Per inspection |
| *State and Federal regulations apply. | | |
| MA Plumbing, fuel and gas code, CMR 248 will be strictly adhered to. Permits are valid for 13 months from date of issuance. | | |

The Bloody Brook runs through the municipal campus and between the school. Due to the high-water table and flooding issues throughout Town, development density is difficult to pursue with bylaws prescribing minimum lot sizes, frontage requirements, and maximum lot coverage by impervious surface. Any development would likely need to remain outside of the 200’ Riverfront Area. With the recent interest in Senior Housing on the northern end of the Municipal campus, the Town has invested in the delineation and approved Abbreviated Notice of Resource Area Delineation from the Conservation Commission; Dec. 15, 2023. Piping crossing the brook and connecting the campus to the school and northward would require additional review and approval from the Conservation Commission. The permitting route and the fee structure through the Wetlands Protection Act would depend on the final development proposal.

The Commonwealth of Massachusetts requires all drillers to be certified by MassDEP.

# 4 Site Options

At project initiation, the project team was provided with three options through which a comparative feasibility assessment could be conducted for a networked geothermal project. The comparative assessment of the techno-economic feasibility of each network option is further detailed in Section 5.

## 4.1 Iteration 1

Iteration 1 is a proposed network that encompasses 25 buildings in the central part of Deerfield (Figure 4-1). In addition to 25 residential buildings in this site, the proposed network includes key buildings including:

- Deerfield Town Hall
- Deerfield Police Department
- Tilton Library
- Deerfield Elementary
- Berkshire Brewing Company


Figure 4-1. Preliminary network design for Iteration 1.

Within this network, currently measured at about 11,000 feet, there is an opportunity to integrate Berkshire Brewing Company – a local brewer that produces 6,000 barrels of beer annually.[20] Industrial processes that often produce “wasted” heat, such as breweries, can be leveraged as a source of additional thermal energy to help thermally balance a networked geothermal system.

## 4.2 Iteration 2

Iteration 2 builds on iteration 1 by extending the network further north into Deerfield (Figure 4-2), capturing additional residential buildings and key commercial buildings including:

- Frontier High School
- South Deerfield Fire Department
- South County Emergency Medical Services

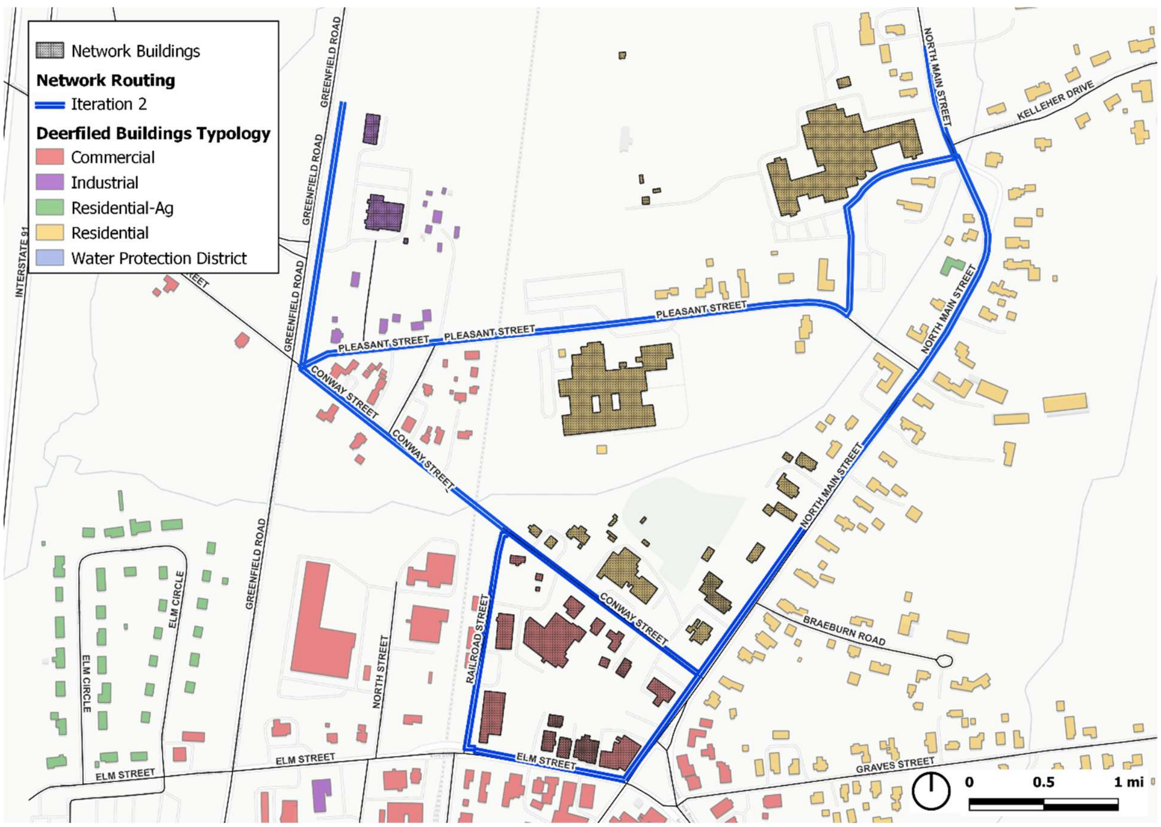


**Figure 4-2. Preliminary network design for Iteration 2.**

It should be noted that this network, currently estimated to be about 16,000 feet, may face some key routing challenges, such as crossing an existing rail line and Bloody Brook which could introduce easement challenges with the Massachusetts Department of Transportation and the town of Deerfield. However, the addition of Frontier High School represents an opportunity to dramatically increase the thermal load served by the network, improving efficiency for the broader network.

[20] Berkshire Brewing Company. https://www.berkshire-brewing.com/about

## 4.3 Iteration 3

The final, and largest, iteration proposed builds on iteration 2 by introducing two additional waste heat sources to the network: Tree House Brewery and Pelican Products to the north. These facilities are not assumed to be served by the network but would be explicitly connected for access to consistent operational waste heat sources.

To be able to integrate these two facilities into the network, the system will need to extend further north to a total length of about 24,000 feet along North Main Street and along either the existing rail line or Interstate 5/Greenfield Road, as shown in Figure 4-3.

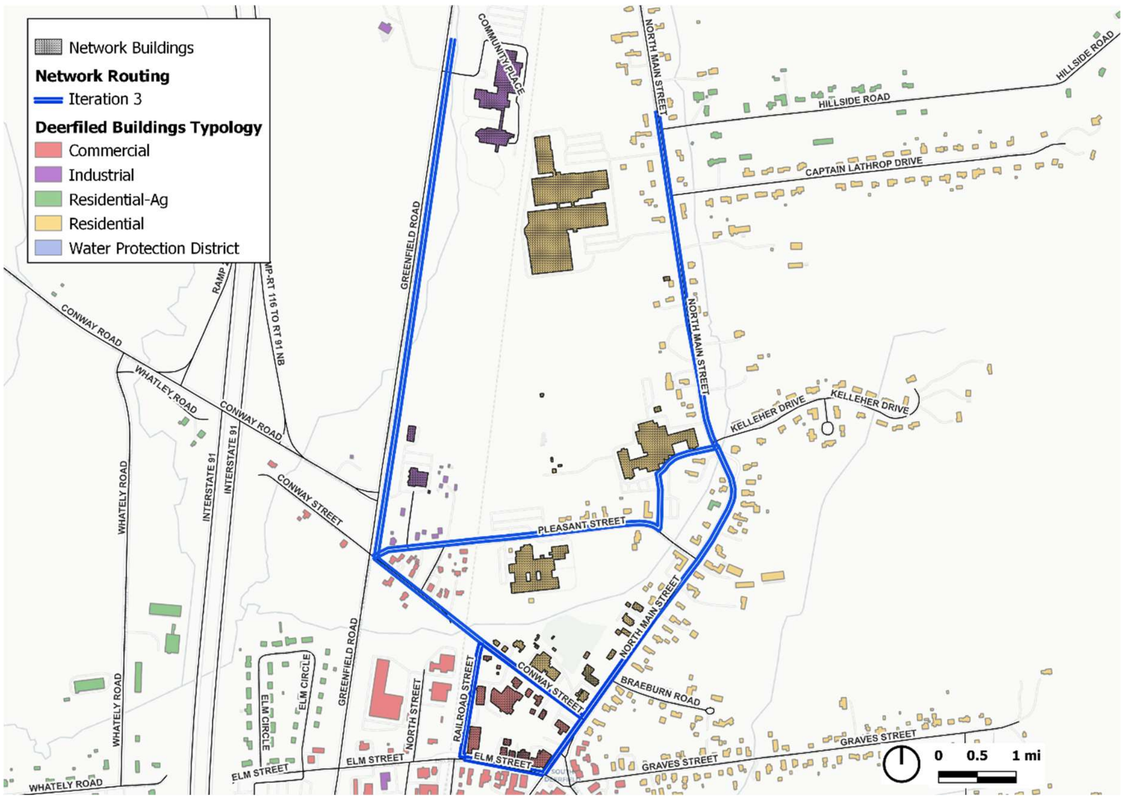


**Figure 4-3. Preliminary network design for Iteration 3.**

## 4.4 Existing Plans for Infrastructure Upgrades

Large infrastructure projects such as networked geothermal can be installed during broader municipal infrastructure upgrades. These projects can include pipe replacement for utilities, roadwork or other excavation activities. Additional housing and campus building infrastructure upgrades are also helpful in the planning for networked geothermal projects. Table 4-1 summarizes Deerfield's planned projects for the near future.

**Table 4-1. Proposed Municipal Projects**

| Year | Project Type | Area | Description |
|---|---|---|---|
| 2027 | Road | Elm St, N. Main | Complete Streets - full depth reclamation |
| 2026 | Building Retrofit | Municipal Campus | 1888 Building Renovation & Addition |
| 2028-2030 | Housing | Municipal Campus | Senior/Mixed-use Housing at the former St. James Church |
| 2028-2030 | Unknown | Municipal Campus | Following 1888 vacant Town Hall building may be repurposed or redeveloped |
| 2026-2031 | Building Retrofit | Deerfield Public School Campus | Air conditioning installation in various areas of the building |
| 2026-2031 | Building Retrofit | Municipal Campus | Police station HVAC design, engineering, construction |
| 2026-2028 | Road | Town Common | Potential closure of Park Street and revitalization of the Town Common & utilities |

# 5 Geothermal and Energy Balance Analysis

This section discusses the analyses completed to assess site feasibility based on local geological conditions and building energy demand for the potential network in Deerfield. Networked geothermal systems consist of three main parts: 1) the ground heat exchange system which consists of geothermal boreholes; 2) the civil infrastructure including the distribution network in the streets and pump house used for circulation; and 3) the individual heat pumps within homes and businesses. Building heating and cooling loads are used to size the ground heat exchange system, with the civil infrastructure used for interconnection.

## 5.1 Bedrock Geology and Ground Heat Potential

Deerfield sits on bedrock predominantly characterized as basin sedimentary rock (Figure 5-1).

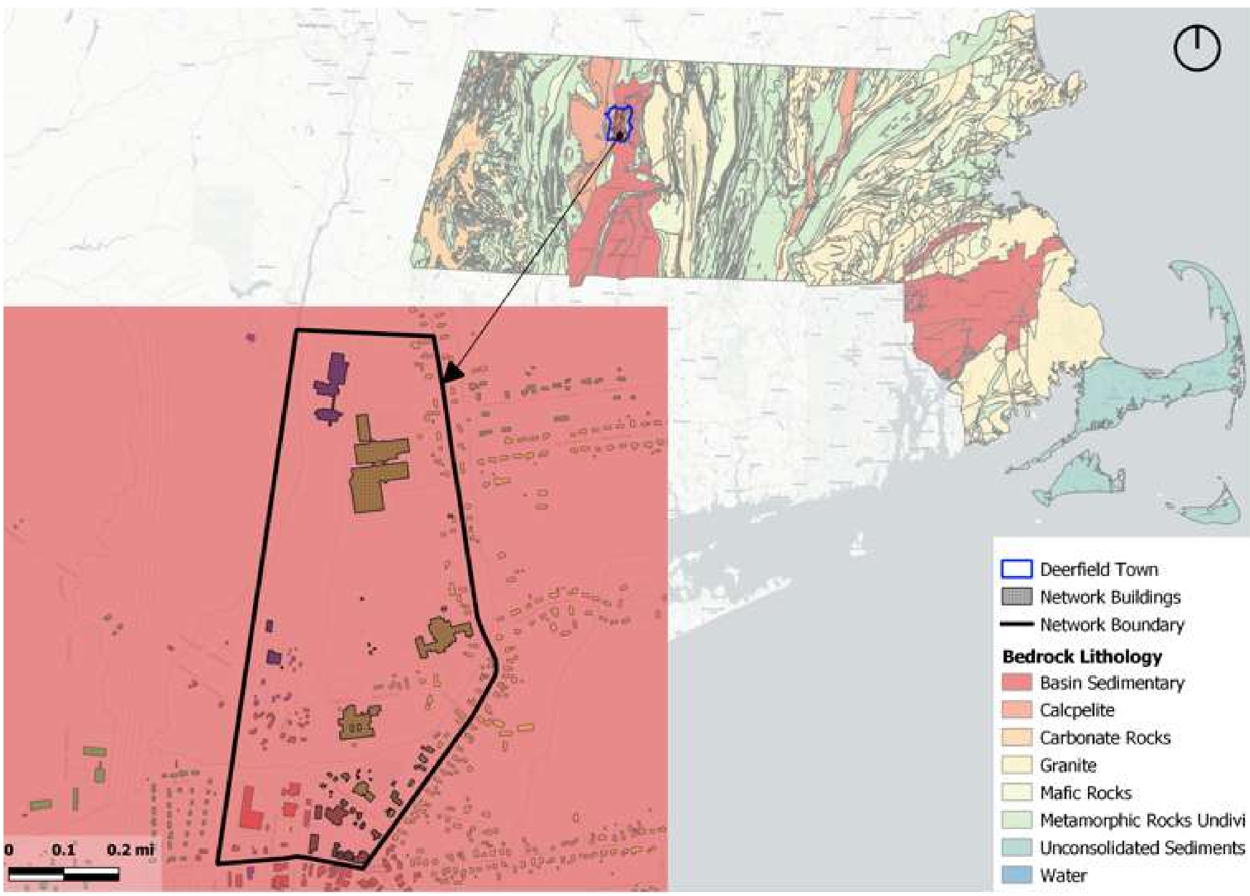


**Figure 5-1. Prevailing bedrock geology in Deerfield, Massachusetts.**

Based on data provided from USGS, this type of bedrock has a typical thermal conductivity estimated at 17 Watts/foot (Figure 5-2).

**Table 5-1. Specific heat extraction (Watts/foot) value by bedrock type, based on 1800 full load extraction hours per year.**

| Rock Type | Specific Heat Extraction (Watts/foot) | Specific Heat Extraction (Watts/meter) |
|---|---|---|
| Extrusive Igneous Rocks e.g., basalt | 13-20 | 40-65 |
| Intrusive Igneous Rocks e.g. granite | 20-26 | 65-85 |
| Metamorphic Rocks e.g. gneiss | 21-26 | 70-85 |
| Carbonate Rocks e.g. limestone | 14-18 | 45-60 |
| Basic Sedimentary e.g. sandstone | 20-24 | 65-80 |
| Gravel, Sand, Saturated Water | 20-24 | 65-80 |
| Clay, Loam, Damp | 10-15 | 35-50 |

The depth to bedrock raster, with a 100-meter resolution, illustrates the thickness of the overburden across Massachusetts. Depth to bedrock within the study area extends to depths ranging from 26 to 72 m (or 85 to 236 feet) below ground surface (bgs). This region of Deerfield generally has the shallowest depth to bedrock within the town.

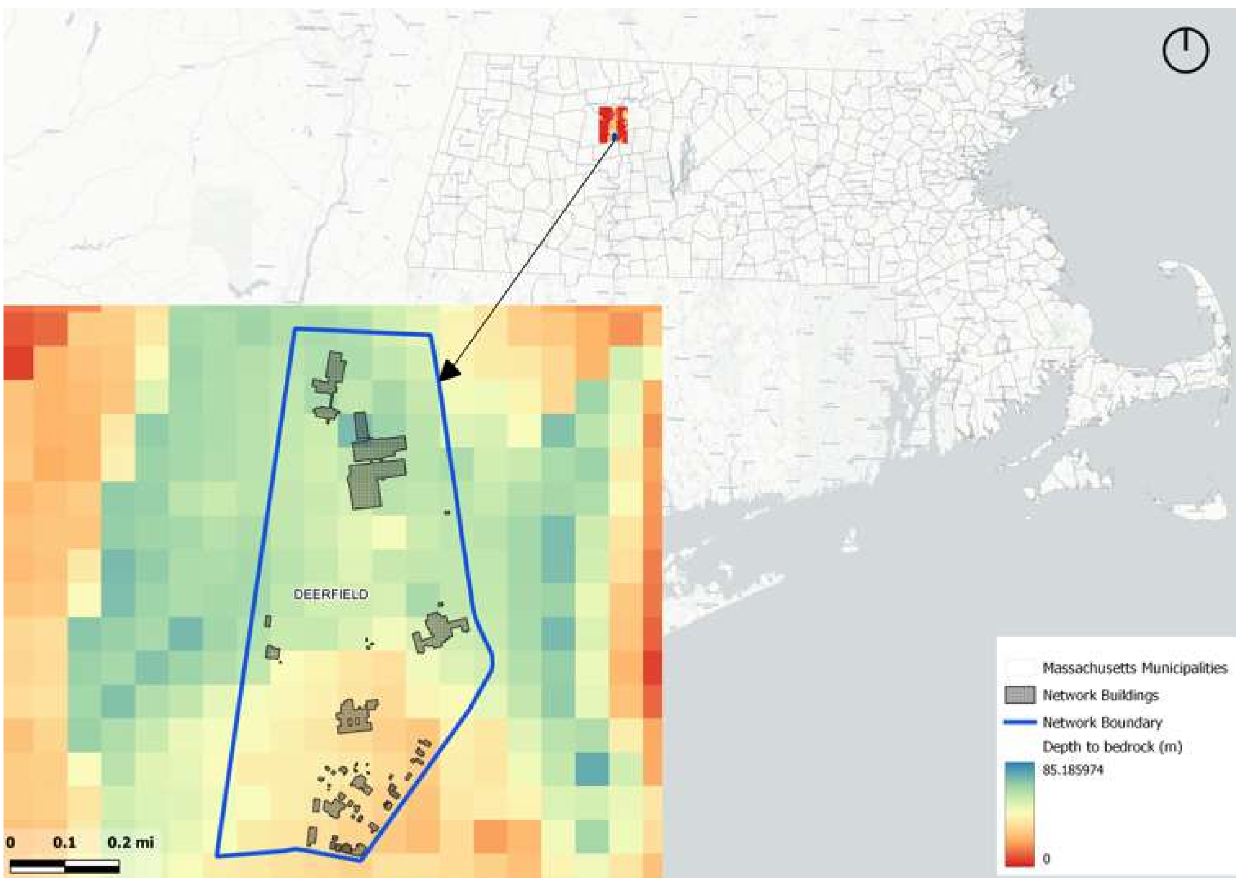


**Figure 5-2. Depth to bedrock in Deerfield, Massachusetts.**

## 5.2 Energy Demand Assessment

A key component of site feasibility study is the energy demand assessment for the potential buildings in each iteration. Information from the Deerfield tax assessor dataset was used to determine the square footage of the potential participants along the network.[21]

Only limited amounts of information were available for establishing loads of actual buildings along the network. Therefore, modelling of each building was done based on NREL's ComStock and ResStock databases based on each building typology. These datasets utilize traditional physics-based energy modelling tools, utility data, and building survey data on typical physical characteristics to generate time series datasets of energy end use for ~500,000 buildings across the United States. To establish estimated heating and cooling load profiles for buildings in the study area, the ComStock and ResStock datasets were referenced to calculate energy use intensities (EUI) and thermal load profiles.

Data were made available by the town of Deerfield for the Deerfield Elementary School, Frontier Senior Center, Tilton Library, and Town Hall Municipal Building. The total energy demand of electricity and natural gas were tabulated and summarized in Figures 5-3 and 5-4. Data summarized in these figures shows an average monthly energy consumption for the last 10 years of available data.

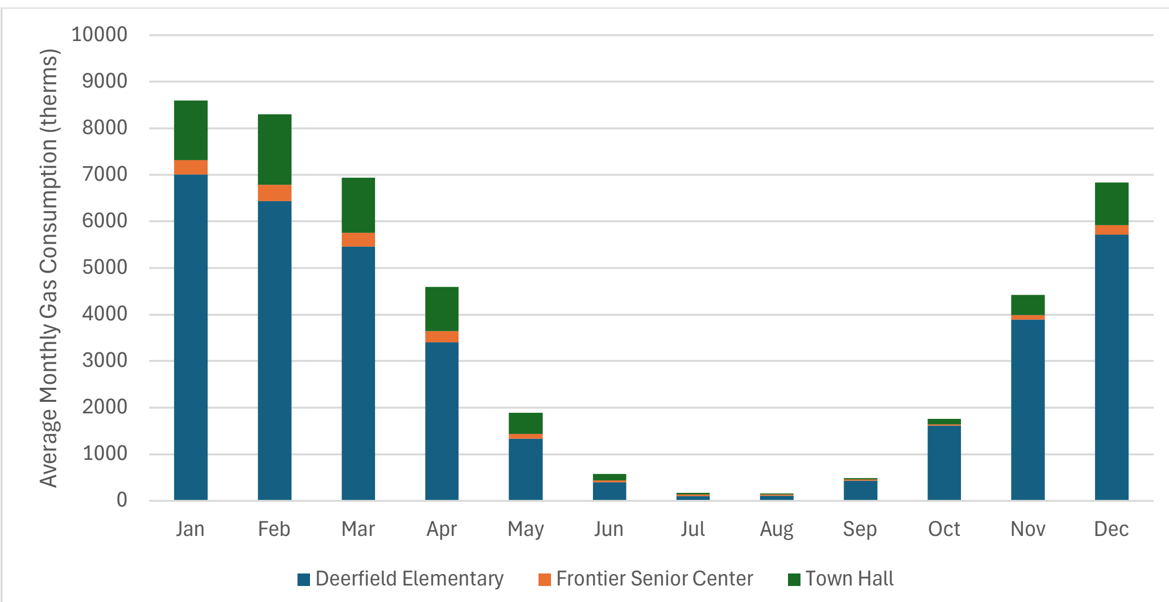


**Figure 5-3. Average Monthly Natural Gas Consumption by Deerfield-Owned Building**

[21] https://next.axisgis.com/DeerfieldMA/

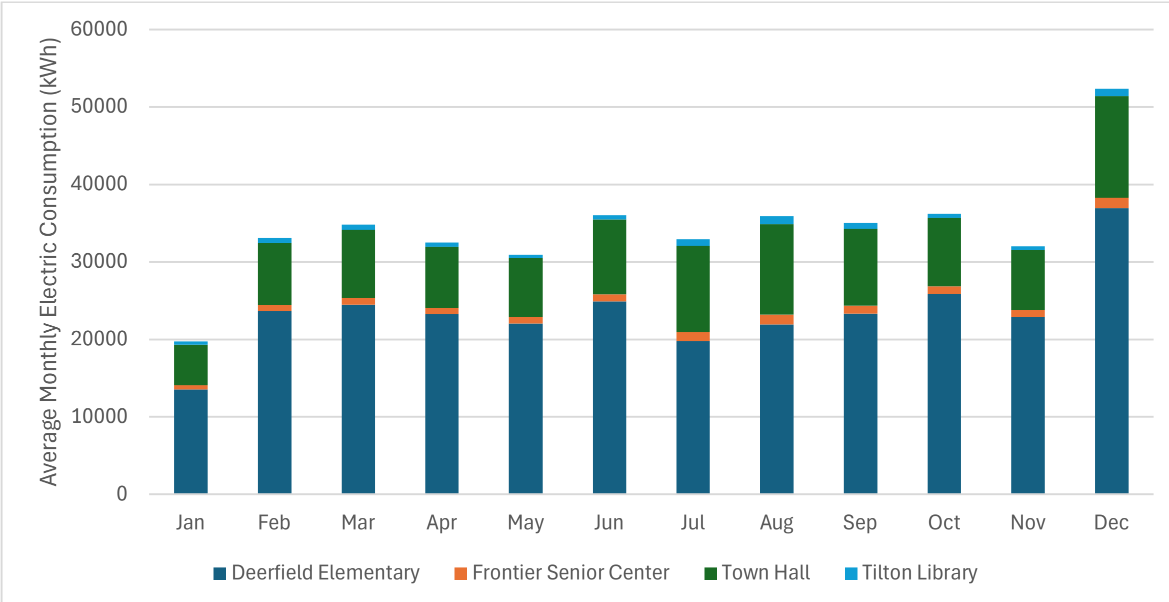


**Figure 5-4. Average Monthly Electric Consumption by Deerfield-Owned Building**

# 6 Site Feasibility Analysis and Conclusions

The feasibility analysis for the site builds on the geothermal and energy balance described in Section 5. Technical and economic parameters were compiled and evaluated to understand the overall feasibility of the proposed project iterations using a comprehensive modelling tool developed by Buro Happold. The tool utilizes building energy demand to screen the potential networked geothermal system against an ASHP alternative which assumes each building would be fit out with individual systems. This screening tool summarizes energy demand while accounting for network construction costs including civil construction, borefield installation, and building level upgrades. Economic outputs utilize RSMeans cost estimation data to provide an order of magnitude cost estimate, present value of the system, and lifecycle utility and operations and maintenance (O&M) costs for comparison between the configurations.

## 6.1 Technical Analysis

Total demand loads for the buildings along each of the network iterations were evaluated to determine the design parameters. Square footage totaled 110,742 square feet for Iteration 1 and 273,991 square feet for Iterations 2 and 3. The total annual network demand was calculated to be approximately 0.9 TWh/year and 1.5 TWh/year, respectively.

Waste heat available in the three iterations was well over the total network demand, however heat that is available during the specific time of need only represented 38%, 42%, and 58% of the demand, respectively. Note that this evaluation does not account for losses of heat in the distribution system which could be significant along the extended iteration 3 loop. Based on the demand requirements and amount of waste heat available, a rough estimate of geothermal wells required to balance the system based on an expected bedrock heat exchange rate of 17 W/ft were calculated (Table 6-1).

**Table 6-1: Borehole count requirements based on various drilling depth scenarios**

| | Number of Boreholes Required | | |
|---|---|---|---|
| **Variable Installation Depth (feet below ground surface)** | **Iteration 1** | **Iteration 2** | **Iteration 3** |
| **500** | 69 | 130 | 120 |
| **800** | 43 | 82 | 74 |
| **1000** | 35 | 65 | 59 |

## 6.2 Economic Analysis

Using a comparative tool developed by Buro Happold, the capital and operational expenses for the proposed geothermal network iterations were developed.

Based on the network demand and system configuration requirements for each of the iterations, capital cost estimates were modeled (Table 6-2). Due to the uncertainty of drilling costs, three variations including $40/linear foot, $60/linear foot, and $80/linear foot were modeled to provide potential ranges in drilling cost associated with each of the iterations.

**Table 6-2. Estimated order of magnitude capital costs.**

| | Modelled Capital Cost ($) | | |
|---|---|---|---|
| **Variable Cost ($/ft)** | **Iteration 1** | **Iteration 2** | **Iteration 3** |
| **40** | $11,003,746 | $ 19,072,143 | $ 24,505,643 |
| **60** | $11,797,246 | $ 20,567,143 | $ 26,000,643 |
| **80** | $12,590,746 | $ 22,062,143 | $ 27,495,643 |

Total capital costs for system construction of networked geothermal systems in Deerfield ranged from $11 million to $27.5 million. It is clear based on this analysis that the cost of extending the network northward in iteration 3 to capture waste heat is a costly investment. The value of capturing waste heat at such a large distance should be studied further to understand the true benefit of this addition to the system and understand return on investment (ROI). Iteration 2, however, had the most effective cost per square foot of conditioned space.

In addition to the upfront capital cost and operational costs including electricity, the model calculates a comparative cost associated with installing ASHPs instead of a TEN. In all iterations and cost scenarios, the cost of ASHPs was less expensive over a 60-year modeled period. Of all iterations studied, the second had the fastest breakeven period at over 50 years.

ASHPs appear to be a much less expensive alternative for these network configurations due to the relatively low population density of the study area which would require significant amounts of piping network. Secondary factors include building diversity, which in all iterations was primarily commercial. If significant amounts of housing were added to the system at a later date, the lifecycle cost of the networked geothermal configuration could be a more effective alternative.

## 6.3 Conclusions and Next Steps

Although the three iterations of networked geothermal systems were all technically feasible, the lifecycle cost of the geothermal network in every iteration was more expensive over a 60-year lifecycle relative to other technologies. Therefore, a geothermal network may not be feasible for this study area of Deerfield if the network's only purpose was to provide a thermal service and there were no other co-located municipal projects to reduce the implementation costs. Alternative heating and cooling technologies should focus on adoption of cold-climate ASHPs (ccASHPs) and individual ground source heat pumps for larger buildings such as the school systems, breweries, and other commercial facilities. Individual home ground source heat pumps could also be an effective building decarbonization alternative.

Re-evaluation of this area should be completed if future housing developments are built along the network path or other economic co-benefits are co-located through municipal improvement projects to reduce the capital cost of the geothermal network. Additionally, if the cost of natural gas rises more than current forecasts, Massachusetts or the US Federal government adopts a carbon tax like Europe, or the rate of pipeline gas failures in the region increases to the point where the local gas utility must invest in a full replacement, then a geothermal network would be a cost competitive solution that should be reconsidered. As this technology matures, the cost of geothermal networks are anticipated to decrease over time as adoption rate and innovations make it a more attractive economic proposition in less densely populated areas such as Deerfield.

The town of Deerfield and its residents have expressed significant interest in this technology and should continue to evaluate different areas to implement this technology as a building decarbonization opportunity.

# Appendix A

| Timestamp | 1. Have you ever heard of geothermal, or networked geothermal as a heating and cooling source? | 2. Is your home connected to Berkshire Gas? | 3. What heating system do you currently have in your home? | 4. (Optional) Approximately, how old is your heating system (in years)? | 5. Do you have a cooling system? | 6. (Optional) If so, what cooling system(s) do you currently have? | 7. (Optional) If you are willing, please share your approximate cost or total kWh per month. | 8. Are you interested in participating in a Geothermal Network? | 9. (Optional) Please use the space below to provide questions, comments, or concerns. |
|---|---|---|---|---|---|---|---|---|---|
| 2025/07/03 7:38:14 PM AST | Yes | No | Electric | | No | | | I would if I wasn't renting. I love the idea of neighborhood geothermal loops | |
| 2025/07/06 5:38:06 PM AST | Yes | No | Furnace | 4 years | Yes | Electric central air | | Not sure | |
| 2025/07/06 5:58:52 PM AST | Yes | No | Electric;pellet stove | 8 | Yes | heat pump | | Yes | I feel community solar may be more practical but I have an open mind. |
| 2025/07/06 6:07:42 PM AST | Yes | No | Furnace;Heat Pump;Electric;Wood stove insert | | Yes | Mini splits | around 1100 KWh/mo | Yes | |
| 2025/07/06 6:08:08 PM AST | Yes | No | Heat Pump | 1year | Yes | Air source heat pump | Donâ€™t yet know | I would say yes, but I am too rural | I think net geothermal is the future for South Deerfield.<br>Lowering operational cost will be important to keeping our taxes from rising too precipitously |
| 2025/07/06 6:12:32 PM AST | Yes | No | Boiler;Heat Pump | Boiler 1960s, 60 K BTU Heat pumps 2018, 12 K more 2024 | Yes | Heat pumps | Ave $194/month, ave 610 kWh/month | No | I hope you can do it. |
| 2025/07/06 8:17:02 PM AST | Yes | No | Furnace | 4 years old | Yes | Air Conditioning | | Yes | I live in a condo development that is controlled by an HOA. |
| 2025/07/06 9:03:37 PM AST | Yes | Yes | Heat Pump | 13 years | Yes | Window ACs | $250 | Yes | Thanks for exploring this option. |
| 2025/07/06 10:20:51 PM AST | Yes | No | Furnace;Boiler;Heat Pump;Electric | 10 years | Yes | Mini splits | | Need to learn more | Do we need to heat with gas to connect to geothermal? |
| 2025/07/07 4:00:38 AM AST | Yes | No | Boiler | | Yes | 18â€ of attic insulation. Window fans at night. | Low kWh usage | Yes | Isnâ€™t this program limited to Berkshire Gas residential customers ? Why wasnâ€™t that explicitly stated ? |
| 2025/07/07 6:29:22 AM AST | Yes | No | Boiler;Heat Pump | 15 year old boiler now rely on two 2023 Heat Pumps | Yes | Heat pumps work great for AC also | $221 per month average | Yes | |
| 2025/07/07 7:23:39 AM AST | Yes | No | Furnace | 40 + _ | No | | ` | as of today I don't know | |
| 2025/07/07 7:37:53 AM AST | Yes | No | Furnace | 33 yrs | Yes | Central air | | Yes | |
| 2025/07/07 8:44:57 AM AST | Yes | No | Boiler | 30-40 | Yes | Central A/C | 6 | Yes | Networked geothermal is a great idea and I'm excited to see Deerfield pursuing this! Many houses within South Deerfield are on oil, however, and neighbors have been switching to air-source heat pumps and/or wood heating systems. I assume that, because our house is far from existing gas infrastructure, we would not be an ideal candidate for participation. |
| 2025/07/07 9:01:04 AM AST | Yes | No | Electric | 30 | Yes | Window air conditioner | 600-1100 | Need more information | |
| 2025/07/07 2:22:33 PM AST | Yes | No | Furnace | 5 | Yes | central AC | | Depends on more information about options for condos not connected to natural gas | Will the July 17 meeting be recorded? I won't be able to to attend live. |
| 2025/07/07 2:51:05 PM AST | Yes | No | Furnace | Not sure. At. Least 20 yrs | Yes | Window ac, fans | $100. last month | Yes | Curious to learn more about this!!! Driving a friend to NH on the 17th. Will this be available to view after the fact? Did have a swamp cooler in CA. |
| 2025/07/07 4:01:51 PM AST | Yes | No | Furnace;Heat Pump | 6 months | Yes | Heat pump ducted forced air | Home has 12.3 kW solar array, so hard to say. | Interested in having municipal buildings on a geothermal system, if possible. | |
| 2025/07/07 6:37:01 PM AST | Yes | No | Boiler;Heat Pump | 3 years | Yes | mini splits | | Yes | |
| 2025/07/08 4:33:28 AM AST | Yes | No | Furnace | 25 | No | Window air conditioning | | I live on the out skirts of town | |
| 2025/07/08 2:20:27 PM AST | Yes | No | Furnace | 10 years? | Yes | Bryant full home | No clue, we have solar panels | No | I support researching geothermal for the town |
| 2025/07/08 10:31:47 PM AST | Yes | No | Electric | 50 yrs | Yes | heat pump | $300 average (product and delivery charges) | Yes | |
| 2025/07/10 11:34:24 AM AST | Yes | No | Furnace | 30 | No | | 6.9kwh | Yes | |
| 2025/07/10 12:38:10 PM AST | Yes | No | Furnace;Heat Pump | about 4 years | Yes | heat pump with backup propane gas furnace | I'd have to dig out bills (for propane and electricity and do some math...) | No | I'm very pleased to see Deerfield examining clean energy! |
| 2025/07/11 1:13:19 PM AST | Yes | No | Heat Pump;and propane backup | 9 months | Yes | heat pump | We have 12.3 kw solar array | Yes | |
| 2025/07/12 8:34:36 AM AST | No | No | Furnace;wood pellet stove with furnace backup | 12 years | No | | $100 - $150 per month | Yes | We have questions about initial cost outlay. |
| 2025/07/12 1:43:09 PM AST | Yes | No | Furnace | 60 | No | | | Yes | |
| 2025/07/13 4:20:10 PM AST | Yes | No | Furnace | 3 | Yes | whole house air conditioner | | No | |
| 2025/07/15 8:38:49 AM AST | Yes | No | Furnace;Boiler | 25 | Yes | Ducted central air | Unknown | Yes | |