Executive Summary

Aging Gas Infrastructure

Natural gas accounts for the majority of the energy use in Massachusetts.[1] Yet more than a quarter of the gas pipes under Massachusetts streets are aging, and must be replaced over the next 20 years. This work will cost gas customers more than $9 billion.[2]

An investment of this scale in fossil-fuel infrastructure is in direct opposition to the State's mandate to reduce emissions 80 percent by 2050. Moreover, because the cost of replacement is spread over 40 years, gas customers, who will ultimately pay for this work, may be funding an obsolete, or "stranded" infrastructure network.

However, aging gas infrastructure in Massachusetts can create an opportunity rather than a problem. The residents and businesses of Massachusetts must decide whether to continue on current trajectory or pursue new paths. The investment must be made, but what type of infrastructure should define our collective future?

The GeoMicroDistrict

This Study explores the feasibility of replacing aging gas infrastructure in Massachusetts with ground-source heat pump (GSHP) systems shared by buildings along a single street segment, or "GeoMicroDistricts." As gas pipes are replaced, individual GeoMicroDistricts could interconnect to form increasingly larger and more efficient systems that could be managed by a thermal distribution utility.

This Study used the best available data on Massachusetts geology, land use, and existing building thermal energy use to assess the feasibility of GSHP systems against typical conditions encountered throughout the state, specifically areas in existing gas utility territories.[3] Street-segment prototypes were then created to represent those conditions at the scale of a GeoMicroDistrict.

Various GSHP systems were evaluated for their ability to meet the heating and cooling loads of street-segment prototypes identified. This Study assumed that an ambient temperature loop, installed within an existing gas utility right-of-way, would provide an interface between loops in the ground and individual buildings. Each building would provide its own heat pump to transfer thermal energy between the ambient loop and its heating and cooling distribution systems.

Meeting Thermal Energy Needs

Ultimately, vertical group-coupled systems provided the best performance across street-segments, meeting 100 percent of the heating and cooling needs of buildings in low to medium density residential and mixed-use commercial districts. However, the imbalance between seasonal heating and cooling loads poses a challenge, as it may result in long-term changes to ground temperatures.

GeoMicroDistricts can resolve this issue by interconnecting a variety of heating loads, and providing a centralized system for supplemental heating and cooling. For example, the surplus of cooling capacity typical to a residential-only area may be offset by the higher cooling loads of a neighboring mixed-use or commercial street. This Study found that the larger and more energy-diverse the system, the better the overall performance. This performance improves as GeoMicroDistricts interconnect and grow, as do the costs of operation.

Further, additional capacity can be created by connecting GeoMicroDistricts with surface water heat pump system (i.e., lakes and rivers), or various other heat sources and sinks. These may range from solar hot water panels to the cooling systems of industrial freezers, ice and hockey rinks, or other producers of waste heat.

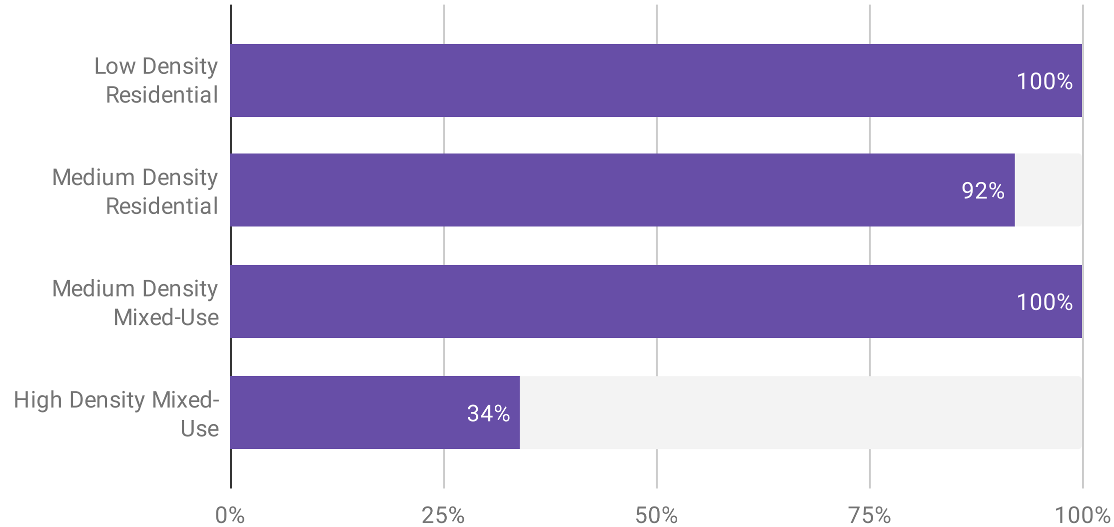
1 Gas provides 46 percent of electric generation and 51 percent of residential heating. Northeast Gas Association. 2017 State of the Industry Report: "Natural Gas in Massachusetts," 2017.

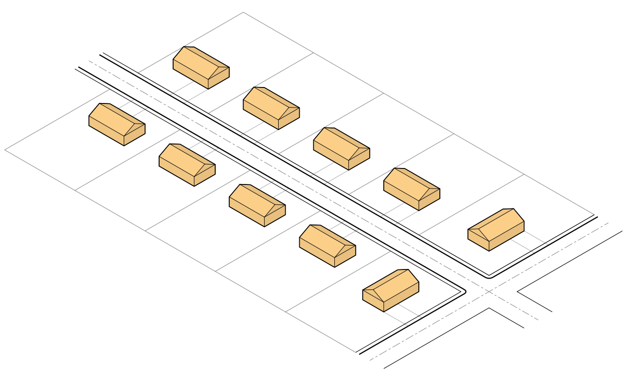
2 Calculated by multiplying the number of miles left to replace by the current average cost per mile, according to Massachusetts Department of Public Utilities, 18-GLR-01 Gas Leaks Report, December 2018.

3 We appreciate the support and data provided by the Massachusetts Clean Energy Center (MassCEC), Massachusetts Department of Energy Resources (DOER), Grey Edge Group, Eversource Energy, and the wealth of information made publicly available by the Massachusetts Bureau of Geographic Information (MassGIS).

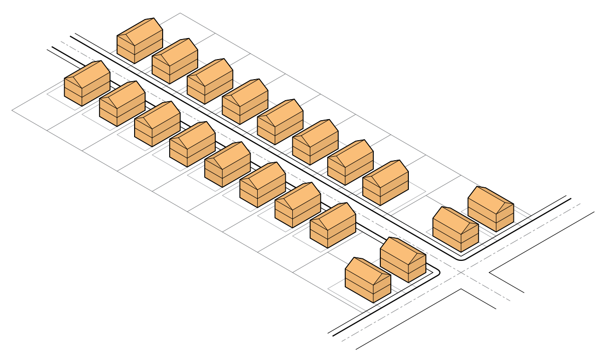
Technical Feasibility: GCHP Closed Vertical

Annual Thermal Energy Loads Met (Interconnected)

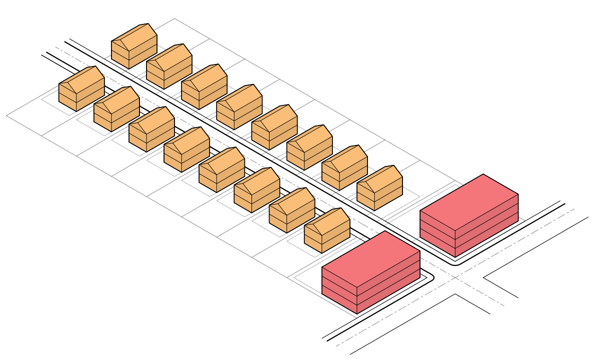




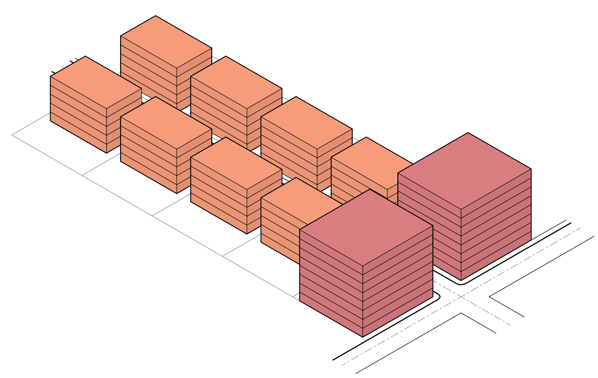
Low Density Residential



Medium Density Residential



Medium Density Mixed-Use



High Density Mixed-Use

Lower Energy Costs

The price of thermal energy purchased from a GeoMicroDistrict depends a number of factors, but is ultimately decided by the Massachusetts Department of Public Utilities ratemaking process. However, unlike natural gas heating, the source of energy for a GeoMicroDistrict is effectively free. There is no fuel cost other than that for the electricity used to power the various pumps and controls. As a result, rates would only reflect the cost of installing and maintaining the system, and customers and utilities are protected from severe fluctuation in fuel prices. Therefore, it is possible to provide thermal energy at rates lower than those for gas.

Speed and Scale of Implementation

The GeoMicroDistrict is a utility-scale approach that re-purposes the existing public utility structure, financing, workforce, and customer base to deliver safe, clean, and affordable heating and cooling. This enables a larger, more rapid, and equitable transition to clean energy than the current building-by-building approach.

An interconnected, renewable thermal energy network also creates benefits for the electricity grid. The use of a GSHP system for cooling would reduce electricity demand during summer peaks, limiting strain on the grid and the potential for outages. Moreover, as buildings move towards electrified sources of heating and cooling, GSHP systems can help lower overall electricity consumption and help utility customers avoid the cost of adding new capacity.

The GeoMicroDistrict represents one side of an energy system composed of two synergistic grids—heat and power, or pipes and wires—that together facilitate a more rapid and equitable transition to clean energy.

Safety Now and in the Future

A GeoMicroDistrict creates much less of a risk to public health than a network of gas pipes, an issue that is critical to Massachusetts given the recent gas disaster in Merrimack Valley and ongoing smaller disasters. Rather than potentially explosive fuel, a GeoMicrodistrict circulates water at around the temperature of tap water, and a pressure close to that of a garden hose.

More importantly, the replacement of gas boilers and furnaces with a GSHP system would result in a significant reduction in greenhouse gas (GHG) emissions. A GeoMicroDistrict could reduce GHG emissions from heating, cooling, and hot water for a typical street segment by nearly 60 percent. Further, GHG emissions associated with the electricity required to operate a GSHP system would decrease over time as the electricity grid adds more renewable energy capacity.

The GeoMicroDistrict thus increases safety now and in the future, providing a safe and clean alternative to natural gas for Massachusetts residents and businesses. It presents a viable strategy to help avert the global climate crisis.

Driving Forward System Change

HEET is actively working with the State and local governments, utility companies, and customers to identify potential locations for one or more GeoMicroDistrict pilot projects in Massachusetts. These pilot projects will provide essential information on the performance and cost of installing and operating a GeoMicrodistrict. HEET and a group of project partners will identify sites in late 2019, with the intention of breaking ground in 2020.

Following successful pilot(s), HEET plans to drive forward the transition from natural gas to clean energy by creating a renewable thermal grid (or “HEET Grid”) from the bottom up, at the speed and scale that this moment in history demands. This Study concludes that the GeoMicroDistrict provides a viable means to achieve this goal, and the implementation of a pilot project is the most important next step in facilitating the transition.