Benefits of Thermal Energy Networks: A Comparison to Air-Source Heat Pumps

Prepared for HEETlabs by Synapse Energy Economics

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Overview and Background

- Decarbonization efforts and the clean energy transition will increase demand on the electric system. ISO New England's 2050 Transmission Study projects that peak demand for the region could rise to 57 GW by 2050 but reducing that peak to 51 GW would save ~$7B according to the study.
- One way to reduce that peak is through thermal energy networks, which don't cause the electric system peak to increase as much as air source heat pumps (ASHP) do.
- HEETlabs hired Synapse Energy Economics to evaluate the benefits (particularly from reducing the system's peak) of transitioning buildings from the gas system to thermal energy networks instead of to ASHPs.
- HEETlabs is a nonprofit climate-solutions incubator spun out of HEET. HEETlabs takes on big problems with no effective actors and shares results widely.

Synapse Energy Economics

- Founded in 1996 by Bruce Biewald and Jean Ann Ramey
- Leader for public interest and government clients in providing rigorous analysis of the electric power and natural gas sectors
- Staff of 40+ includes experts in energy, economic, and environmental topics
- Consults on a variety of projects related to New England’s wholesale markets, Massachusetts utilities’ energy efficiency planning, decarbonization of the gas system, and the future of clean heat

Analysis

Methodology

We compared thermal energy networks (networked ground source heat pumps) against a baseline of ASHPs:

1. Synapse determined load shapes for ASHPs and thermal energy networks using Synapse's Thermal Network Assessment model.
2. Using the load shapes, the team determined the kWh and kW savings from switching to thermal energy networks, as compared to switching to ASHPs.
3. Finally, Synapse calculated the total avoided costs using kWh and kW savings and avoided costs ($/kWh and $/kWh) from AESC 2024.

Sources Used in Analysis

Avoided Energy Supply Components in New England (AESC) 2024

Avoided cost values ($/kW) for energy, capacity, price suppression, PTF (pool transmission facility) transmission, and greenhouse gas emissions

- Relies on ISO NE's 2050 Transmission Study transmission values
- More information on AESC 2024 is available here

MA 2025-2027 Plan BC Model

Avoided distribution costs reported by electric distribution companies – blended statewide value in most recent years

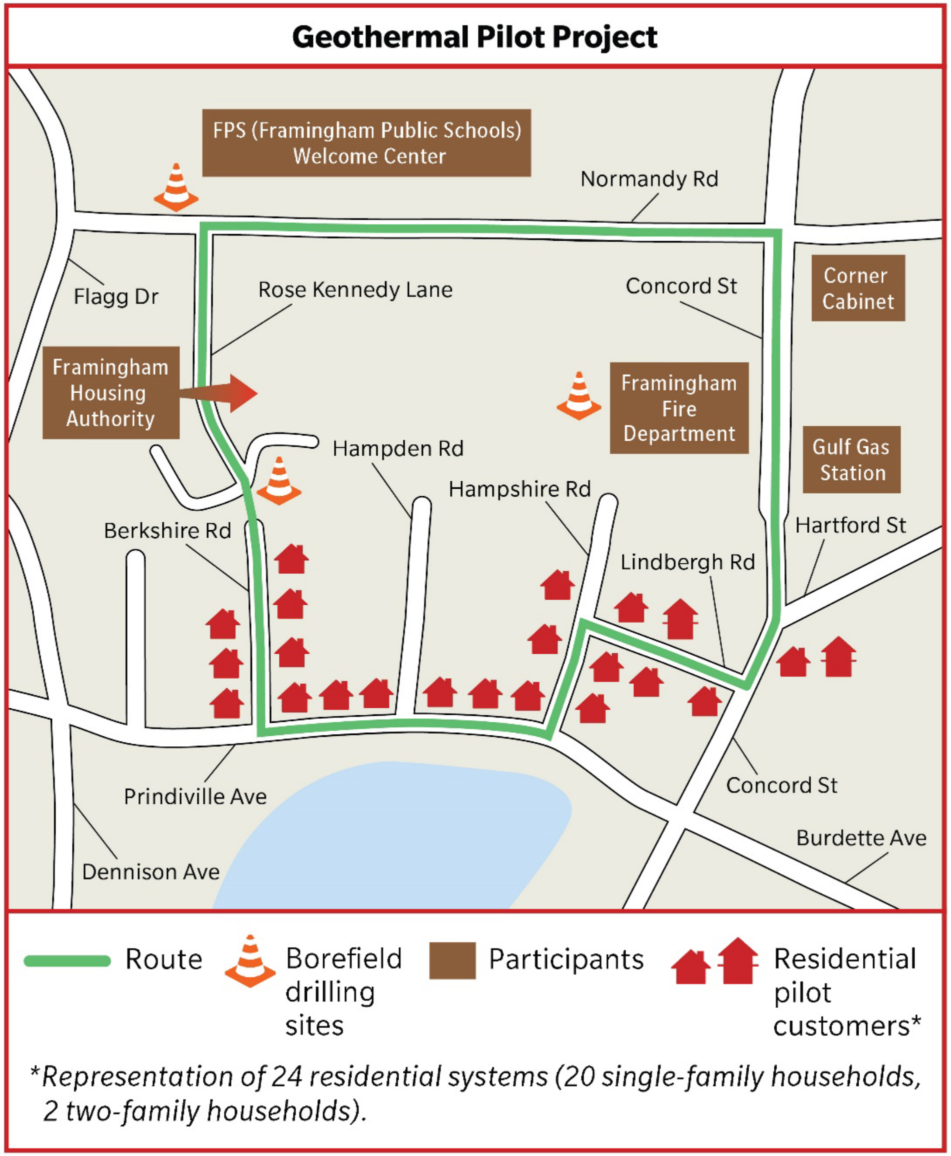
- Information on the MA 2025-2027 Plan Benefit-Cost Models is available here

Synapse's Internal Thermal Network Assessment Model

Load shapes for thermal energy networks and ASHPs

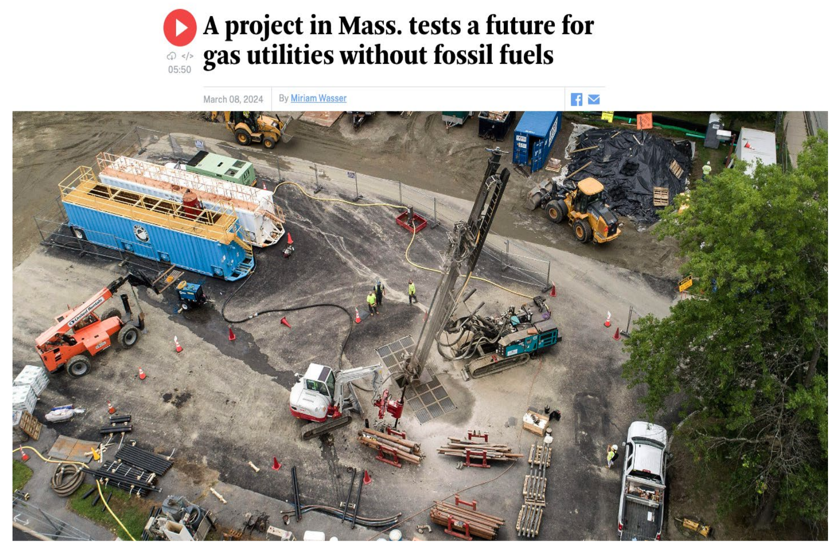
- GSHP COP from NYSERDA's 2019 report "New Efficiency: New York Analysis of Residential Heat Pump Potential and Economics."
- Thermal Network COP from in Xcel Energy's Colorado Mesa University geothermal network case study.

Spotlight: Eversource Install Framingham, MA Thermal Network



Source: https://www.eversource.com/content/residential/about/transmission-distribution/projects/massachusetts-projects/geothermal-pilot-project

Commissioned: Fall 2024



Source: https://www.wbur.org/news/2024/03/08/networked-geothermal-eversource-framingham-pilot-project-decarbonization

Key Assumptions

- This analysis only estimates the *incremental benefits* of thermal energy networks compared to baseline ASHPs, because gas utilities would install thermal networks where financially viable.
- Climate Zones: mild v. cold MA winter (DOE Climate Zones 4 and 5)
- ASHPs: 50/50 mix of mini-splits and ducted heat pumps
- Thermal networks:
  - Infrastructure lifespan: 50 years
  - COPs: COP based on NYSERDA GSHP vs. COP CMU thermal network case study
  - Each network size: roughly based on Framingham pilot and adjusted for scalability - 32 residential buildings (128 total units) and 5 commercial buildings
- A total of four scenarios were modeled: two climate zones for each COP assumption.

Results and Findings

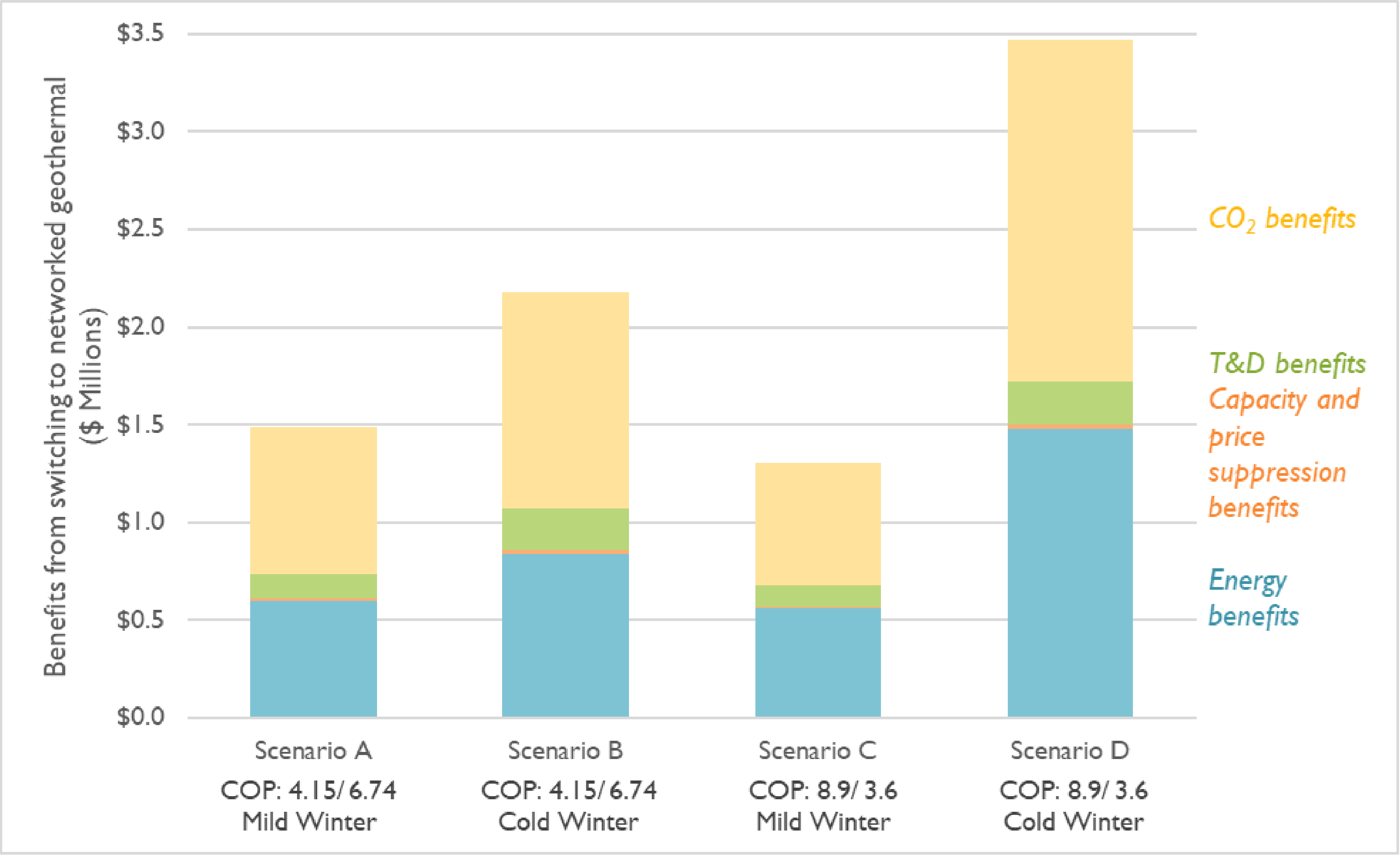
Scenario Results

Table 1. Benefits from switching to thermal energy networks (2024 $M)

	Scenario A	Scenario B	Scenario C	Scenario D
	Mild Winter	Cold Winter	Mild Winter	Cold Winter
Heating/Cooling COP for Networked Geothermal	4.15 / 6.74	4.15 / 6.74	8.9 / 3.6	8.9 / 3.6
Annual Electric Energy Savings (kWh)	149,404	216,810	129,264	355,433
Annual Capacity Savings (kW)	39	54	96	133
Winter Peak Load Reduction (%)	26%	25%	62%	62%
Energy Benefits	$0.60	$0.84	$0.56	$1.48
Capacity and Price Suppression Benefits	$0.01	$0.02	$0.01	$0.02
Transmission Benefits	$0.04	$0.07	$0.03	$0.07
Distribution Benefits	$0.09	$0.15	$0.08	$0.15
GHG Benefits	$0.75	$1.11	$0.62	$1.75
Total Benefits (1 network)	**$1.5**	**$2.2**	**$1.3**	**$3.5**
Total Benefits (1,500 networks)	**$2,232**	**$3,274**	**$1,957**	**$5,207**

Scenario Results

Figure 1. Benefits from switching to thermal energy networks (2024 $M) (1 network)



Findings

- Each thermal network creates **$1.3M-$3.5M in benefits**.
- When that is scaled up to 1,500 systems, the range of benefits increases to roughly **$2B-$5.2B.**
  - 1,500 systems roughly aligns with the number of buildings recommended to switch to ground-source heat pumps to meet MA targets in the 2050 Clean Energy and Climate Plan (~195,000 homes and ~140M sq. ft commercial space)
- Installing thermal energy networks would reduce winter peak by **25-62 percent** for connected buildings.

Takeaways

- Transitioning more Massachusetts buildings to thermal energy networks instead of to ASHPs will help reduce electrification measures' impacts on the electric system peak.
- Coordination across gas and electric utilities is necessary to transition gas customers to the electric system in a way that brings ratepayers and utilities the most benefits—specifically in this instance, identifying potential locations for thermal energy networks.

Future Research

- As more gas utilities construct thermal energy networks, additional data on the efficiencies of these systems can be used to expand and refine this analysis.
  - Thermal networks have higher efficiencies than GSHPs: when buildings have simultaneous heating and cooling needs, heat rejected into the loop to cool one building can be used to heat a different building
- Future analysis could explore locational benefits and more precisely calculate distribution benefits than the statewide representative values used here.
  - The distribution costs avoided by a given project are locationally dependent, and utilities will locate networked geothermal systems where they are most cost-effective
  - Overall distribution system investment will increase alongside electrification efforts, which may drive up $/kW costs
- Future analysis could explore the total costs of these projects for both gas and electric utilities to provide a more complete assessment and how to coordinate tactical deployment.

For any questions or comments please contact:

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Appendix: Benefits Overview

- Capacity Benefits:
  - The costs avoided when a reduction in peak load avoids the need for additional firm capacity in the capacity market.
- Price Suppression/Demand Reduction Induced Price Effect (DRIPE) Benefits:
  - The reduction in prices in the wholesale markets for capacity and energy resulting from reduced demand.
- Transmission and Distribution Benefits:
  - The costs of the deferred or avoided T&D investments from a reduction in peak load. Such T&D costs include those from building new transmission facilities or upgrading existing lines. MA program administrators use avoided regional pool transmission facility (PTF) and avoided local distribution costs in their benefit cost modeling.
- Non-Embedded Environmental Benefits:
  - Greenhouse gas damages avoided from a reduction in load, as approximated by the social cost of carbon. The non-embedded environmental benefits exclude those benefits from Regional Greenhouse Gas Initiative (RGGI) and MA's 310 CMR 7.74 and 7.75 regulations, which are included in AESC 2024 modeling of energy prices.

