

Massachusetts: Grid Impacts of Geothermal Heat Pumps for Residential Buildings

Massachusetts is expected to experience a fundamental shift in its electricity demand profile as electrification accelerates, particularly for space heating, with demand likely transitioning from summer peaking to winter peaking. This shift will make managing winter peak demand critical to maintaining grid reliability and containing infrastructure costs.

This analysis is part of a [three-state study](#) — including Texas, Massachusetts, and Pennsylvania — that examines the system impacts of geothermal heat pump (GHP) (also called ground-source heat pump) deployment across climates, building types, and multiple adoption scenarios under both current and future load conditions.

In Massachusetts, the analysis focuses on residential buildings, including single-family and multifamily homes, where heating and cooling demand often drives the system peaks. GHPs are particularly well-suited to these conditions due to their ability to maintain higher efficiency during extreme outdoor temperatures, reducing both peak demand and total energy consumption. The analysis also considers the benefits of serving residential buildings through a thermal energy network (TEN) in mixed-use settings, where residential and commercial load diversity can improve system efficiency.

The study evaluates the impacts of GHPs in Low (2%), Medium (10%), and High (20%) Adoption Scenarios in single-family and multifamily homes in Massachusetts under two timeframes: Today (2025), based on current load profiles; and the Electrified Future (2040), reflecting electrification across transportation, industry, and buildings, where homes would receive GHPs instead of air source heat pumps.

Key Takeaways

- Residential GHP deployment could substantially reduce Massachusetts's peak electricity demand and deliver meaningful utility system savings. Investing in GHPs can reduce peak electricity demand by up to 0.02 GW in Today's timeframe (2025) and an estimated 7.5 GW in the Electrified Future timeframe (2040), increasing to as much as 8.8 GW in 2040 with strategic deployment of thermal energy networks (TENs).
- Residential GHP deployment delivers overall utility system savings in both Today and Electrified Future timeframes, with savings increasing from up to \$4.7 billion in 2025 to approximately \$12.5 billion in 2040, driven primarily by avoided generation capacity investments.
- Residential GHP deployment increases load factors, improving utilization of the electric system and helping place downward pressure on electricity rates for all customers.
- While current GHP installation costs exceed quantified utility system savings, the cost gap narrows substantially in the Electrified Future. Residential GHP systems in Massachusetts currently average approximately \$15,430 per ton. Achieving a total installed cost of approximately \$12,380 per ton in 2025 dollars (about \$4,390 per ton incremental to air source heat pumps) would make GHP deployment cost-effective based on quantified utility system savings alone, suggesting an installed cost target for market transformation. Some European markets, such as Switzerland, have achieved a similar scale of cost reductions, indicating that policies encouraging broader adoption could help drive down costs and unlock these utility system savings.
- Massachusetts is one of the states that is furthest along in piloting TENs. Strategically deployed, TENs can improve GHP performance and impact, and show potential to lower costs. Continued efforts to pilot and apply learnings from early projects can help accelerate overall GHP deployment.
- Residential GHP deployment can make a meaningful contribution toward Massachusetts's climate goals. The modeled 20% residential adoption scenario in Today's timeframe (2025) could achieve approximately 43% of the 2025 building sector emissions reduction target, and roughly 4% of the 2040 economy-wide emissions reduction target.
- The Massachusetts Department of Public Utilities, legislature, and utilities can accelerate GHP adoption through expanding utility programs, aligning utility cost-benefit methodologies with their full system value, setting utility targets that support peak demand reduction and better grid utilization, and establishing a framework to enable large-load customers seeking interconnection to expedite connection by funding GHP deployment.

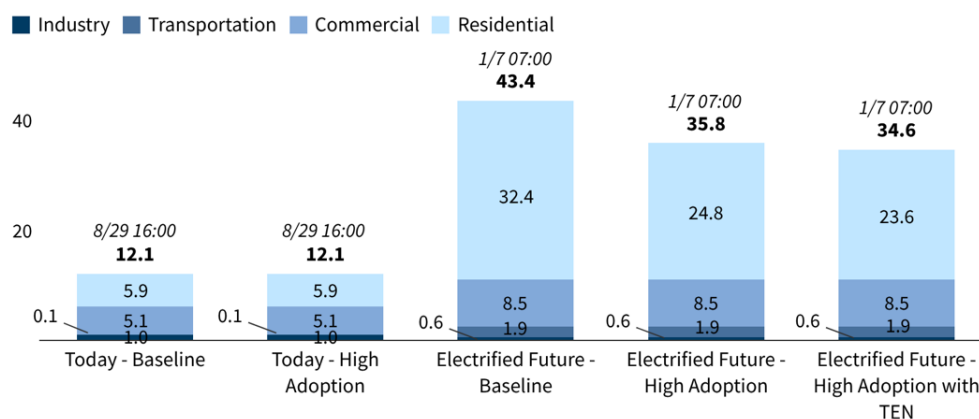
Peak Load Reduction and Grid Impact

GHP deployment consistently reduces electricity use during system peak hours. Although statewide peak demand reductions are modest under today's grid conditions, GHPs can substantially reduce peak electricity demand in an electrified future. Applying GHPs to 20% of single-family and multifamily homes (High Adoption Scenario) reduces statewide peak electricity demand by approximately 0.02 GW in Today's timeframe and 7.5 GW in the Electrified Future timeframe (Exhibit 1). Incorporating TENs into the High Adoption Scenario further reduces peak demand by as much as 8.8 GW in 2040 due to efficiency gains from load diversity across buildings.

Peak demand reductions scale approximately linearly with GHP adoption across all scenarios analyzed, indicating that GHP savings are highly coincident with Massachusetts's peak electricity demand hours (Exhibit 2). GHP adoption also modestly increases Massachusetts's statewide electric load factor across all scenarios (approximately 1%–6%, depending on the scenario). Higher load factors indicate improved utilization of the electric system, which can help place downward pressure on electricity rates for all customers by spreading infrastructure costs across a larger number of kWh.

Exhibit 1

MA peak demand contribution by sector and scenario (GW)



Peak hours vary for each scenario and are noted above.

Source: RMI analysis



Exhibit 2

MA 2025 and 2040 peak load and energy reduction by scenario

Scenarios	2025					2040				
	Peak Hour: 4 p.m. Aug 29					Peak Hour: 7 a.m. Jan 7				
	Peak (GW)	Peak Reduction (GW, %)	Annual Total (GWh)	Total Energy Reduction (GWh, %)	Load Factor*	Peak (GW)	Peak Reduction (GW, %)	Annual Total (GWh)	Total Energy Reduction (GWh, %)	Load Factor*
Baseline	12.1		54,591		51%	43.3		114,628		30%
Low	12.1	0.002 (0.01%)	54,793	-202 (-0.4%)	52%	42.6	0.8 (2%)	114,534	94 (0.1%)	31%
Medium	12.1	0.008 (0.07%)	55,601	-1,010 (-1.9%)	52%	39.6	3.8 (9%)	114,156	471 (0.4%)	33%
High	12.1	0.02 (0.14%)	56,612	-2,021 (-3.7%)	53%	35.8	7.5 (17%)	113,685	943 (0.8%)	36%

*Load factor is calculated as average load divided by peak load.

Source: RMI analysis



Economic Value

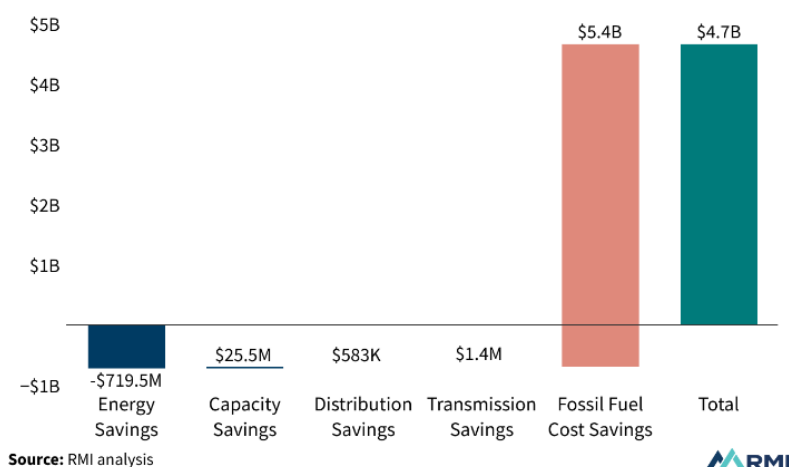
Utility system savings

GHP deployment delivers overall utility system savings in both timeframes with substantially greater savings in the Electrified Future.

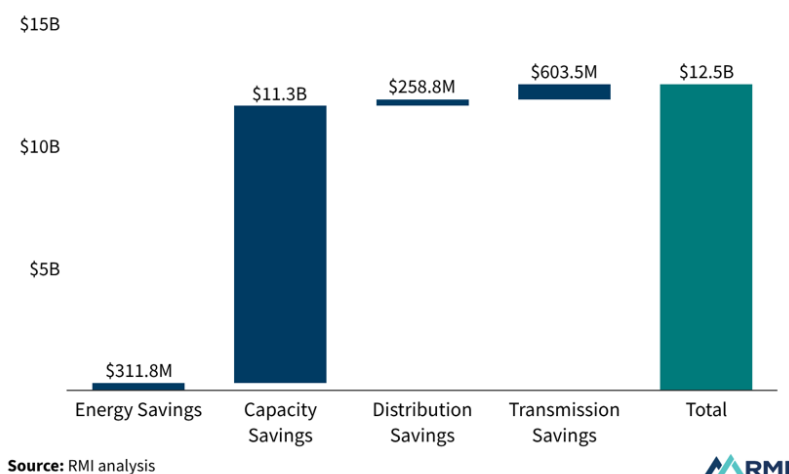
In Today's timeframe, increased electricity consumption from GHP adoption results in higher electricity system costs, as modest summer peak demand reductions are insufficient to fully offset the increased energy consumption. However, replacing natural gas and fuel oil heating with GHPs produces substantial wholesale fossil fuel savings, resulting in overall utility system savings overall. In the Electrified Future timeframe, the large reduction in peak electricity demand savings relative to a baseline with air source heat pumps produces substantial capacity savings,ⁱ which drive the majority of utility system savings. Combined with modest energy, transmission, and distribution savings, GHP deployment results in approximately \$12.5 billion in overall utility system savings under the High Adoption (20%) scenario.

Exhibit 3

MA 2025 High Adoption Scenario utility system savings



MA 2040 High Adoption Scenario utility system savings



ⁱ The Electrified Future is based on the 2024 Annual Decarbonization Pathway central scenario, which projects that 76% of residential space heating is electrified by 2040 and 94% by 2050. Although the scenario includes a mix of heating technologies, this analysis assumes buildings receiving GHPs would otherwise have installed air source heat pumps, the predominant technology.

Customer bill savings

Customer utility bill savings are smaller than total utility system savings in both Today's and Electrified Future timeframes, suggesting that current retail electricity rates do not fully reflect the system value provided by GHPs. Customer bill savings are based on full retail electricity rates, which include utility costs, utility returns, program costs, and other policy-related charges, whereas utility system savings reflect only avoided utility costs.

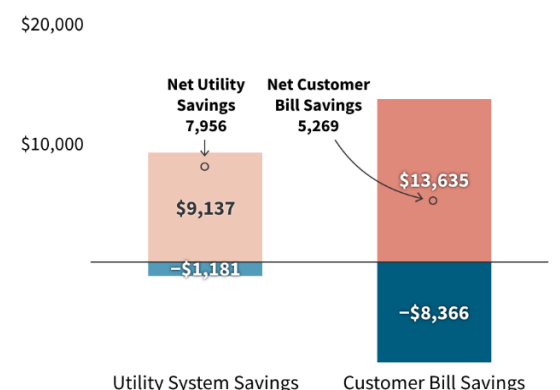
In Today's timeframe, utility system savings exceed customer bill savings, indicating that GHPs are currently undervalued under Massachusetts's existing utility rate structures. The gap is even larger in the Electrified Future timeframe, where substantial generation capacity savings resulting from GHP-driven peak demand reductions account for much of the additional utility system value. It is important to note, however, that the 2040 values are not directly comparable, as they compare future avoided generation capacity costs with today's retail electricity rates.

Exhibit 4

MA per unit savings (2025)

20-year net present value

Electricity System Savings Utility Fuel Cost
Savings Electricity Bill Savings Fossil Fuel Bill Savings



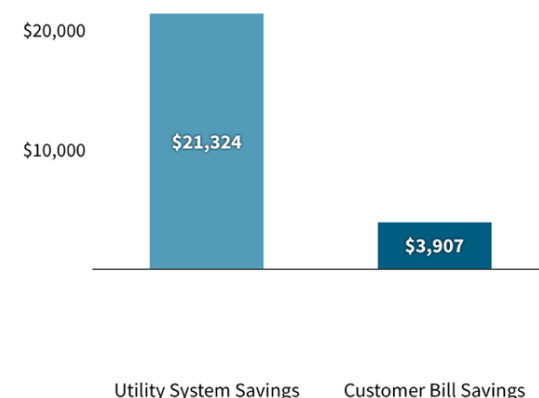
Source: RMI analysis



MA per unit savings (2040)

20-year net present value

Electricity System Savings
Electricity Bill Savings



Source: RMI analysis



Cost & Cost gap

While current GHP installation costs exceed quantified utility system savings, the cost gap narrows substantially in the Electrified Future (Exhibit 5). Even if installed costs were reduced by half, a substantial gap would remain between total GHP system costs and quantified utility system savings in Today's timeframe, when electricity demand peaks in the summer and natural gas remains the dominant heating fuel. In the Electrified Future timeframe, however, the much larger utility system savings associated with GHP deployment significantly narrows the cost gap, making utility-system cost-effectiveness a more achievable target.

Looking ahead, Massachusetts will need to electrify heating in buildings to achieve its climate goals, making the Electrified Future an increasingly likely long-term outcome to plan for. Using the utility system savings projected for the Electrified Future as the benchmark, current residential GHP installation costs in Massachusetts would need to decline from an average of \$15,430 per ton (roughly \$77,150 for a single-family installation with a 5-ton system) by approximately 20% for GHP deployment to become cost-effective based on utility system savings alone. This corresponds to a total installed cost of approximately \$12,380 per ton (equivalent to an incremental cost of approximately \$4,390 per ton relative to an air source heat pump, and roughly \$61,870 for a single-family installation with a 5-ton system). This benchmark could serve as an installed cost target for policies aimed at accelerating market scale and cost reductions.

While the cost difference between thermal energy networks (TENs) and individual GHP systems is difficult to predict, TENs can provide greater value in applications with sufficient load diversity. Existing studies reach different conclusions on installed costs, with some finding that load diversity across connected buildings can reduce the amount of required ground heat exchange infrastructure and lower project costs,¹ while others estimate higher installed costs for district systems.²

However, in applications with sufficient load diversity, TENs reduce both electricity consumption and peak demand compared to individual GHP systems and therefore, if they can be deployed at comparable cost, become a compelling option. In cases where TENs are deployed as non-pipeline alternatives to replace aging natural gas infrastructure, a portion of the network cost may also offset infrastructure investments that would otherwise be required for gas system replacement,³ further improving overall project economics.

Although Massachusetts has one of the most developed GHP markets in the United States, GHP deployment still represents a tiny share of the broader heating market. Continued market expansion, workforce development, and technology innovation present opportunities to further reduce installed costs and help achieve utility system cost-effectiveness. Massachusetts is also one of the states that is furthest along in piloting TENs. Continued efforts to pilot and apply learnings from early projects can help accelerate overall GHP deployment as well.

Exhibit 5

MA GHP total system incremental cost by penetration level

Scenario	Number of Dwelling Units	GHP Tons Across All Units	GHP Incremental Cost Against Gas Furnace (billion \$)	2025 Utility System Savings (billion \$)	GHP Incremental Cost Against ASHP (billion \$)	2040 Utility System Savings (billion \$)
Low	58,534	285,000	3.3	0.5	1.8	1.3
Medium	292,872	1,424,000	16.5	2.3	9.2	6.3
High	585,743	2,849,000	33.1	4.7	18.4	12.5

Source: RMI analysis



Emissions Savings

GHP deployment can make a meaningful contribution toward Massachusetts's climate goals by reducing emissions from both electricity use and on-site fossil fuel combustion. Massachusetts has established ambitious greenhouse gas emissions limits that will require substantial improvements in energy efficiency and widespread heating electrification to decarbonize the building sector.ⁱⁱ The modeled 20% residential adoption scenario in Today's timeframe could contribute approximately 43% of the 2025 building-sector emissions reduction target, 23% of the 2030 target, and roughly 4% of Massachusetts's economy-wide emissions reduction target by 2040.

Exhibit 6

MA emissions reductions by timeframe for High Penetration Scenario

Timeframe	Annualized Emission Reduction (metric tons)		20-Year Lifetime Emission Reduction (metric tons)	
	Per Unit	Total	Per Unit	Total
2025	4.9	2,855,813	98	57,116,260
2040	0.1	67,707	2	1,354,140

Source: RMI analysis



ⁱⁱ [The Massachusetts Clean Energy and Climate Plan for 2050](#) establishes an economy-wide greenhouse gas emissions limit of at least 75% below 1990 levels by 2040, equivalent to a reduction of approximately 70 MMTCO₂e from the 1990 baseline of 94 MMTCO₂e. [The Clean Energy and Climate Plan for 2025 and 2030](#) establishes building-sector emissions sublimits of 17.2 MMTCO₂e in 2025 (a reduction of 6.6 MMTCO₂e from the 1990 baseline of 23.8 MMTCO₂e) and 12.5 MMTCO₂e in 2030 (a reduction of 11.3 MMTCO₂e).

Policy Recommendations

In colder weather states like Massachusetts, the prospect of growing winter peak electricity demand poses new challenges to the electric grid, especially as annual peaks are expected to shift from summer to winter. Massachusetts's policy and regulatory framework can continue adapting to this shift by supporting strategies such as ground-source heat pumps that mitigate winter peak demand while lowering utility system costs. Several actions by Massachusetts utilities and policymakers can help better capture these grid benefits:

- **Adapt peak reduction targets to include winter months:** Mass Save planning has begun to recognize winter peak management as an important planning objective, but utility peak reduction efforts have historically focused on summer demand and do not yet include a robust set of offerings or explicit goals for winter peak reduction. Utilities and regulators can adapt peak reduction targets to include winter months, providing a stronger foundation for recognizing the winter demand reduction benefits of GHPs as annual system peaks shift from summer to winter.
- **Update utility cost-benefit methodologies:** To ensure that the full value of GHPs is captured, regulators can update utility cost-benefit methodologies to better recognize the value of winter peak demand reduction and evaluate GHPs against appropriate future electrification baselines. More comprehensive recognition of these benefits can support larger customer incentives and broader deployment of ground-source heat pumps.
- **Expand GHP incentives:** Mass Save already incorporates significant incentives for GHPs (up to \$13,500 per home versus \$8,500 per home for air source heat pumps) into its customer programs, providing a strong foundation for broader deployment. Utilities and regulators can continue expanding these programs to more fully reflect the customer and utility system benefits of GHPs.
- **Incorporate thermal energy networks into utility system planning:** Building on Massachusetts's utility-scale TEN pilots, utilities can identify locations where shared geothermal infrastructure can serve as a cost-effective non-pipe alternative to avoid investments in the natural gas distribution system. Coordinating deployment with both electric and gas system planning can maximize infrastructure savings while delivering the greatest grid benefits.
- **Invest in GHPs and TENs as strategic priorities:** As Massachusetts updates its investment priorities for Regional Greenhouse Gas Initiative (RGGI) proceeds and other state funding sources, GHPs and TENs can be more fully incorporated as strategic demand-side resources that improve grid management while supporting Massachusetts's electrification and climate goals. These funding sources can complement utility programs by funding customer energy programs outside of utility bills, helping accelerate GHP deployment and market development.

Limitation of the Analysis

1. The economic analysis uses a 20-year net present value period based on the expected lifetime of indoor GHP equipment. However, geothermal bore fields can last approximately 50–100 years, allowing the ground-loop infrastructure to serve multiple generations of indoor equipment. As a result, subsequent GHP replacements would not require the full initial investment, and the longer-term economics of GHP deployment may be more favorable than reflected in this analysis.
2. The GHP cost analysis relies on a simplified \$/ton approach that combines drilling, equipment, installation, and other hard and soft costs. In practice, these cost components do not all scale proportionally with system capacity: some costs scale more directly with system size (e.g., piping), while others have a higher fixed cost component (e.g., drilling). Because GHP installations can have a significant share of fixed costs, scaling total costs linearly on a \$/ton basis may overestimate costs particularly for larger systems where those fixed costs are spread across greater system capacity.
3. The TEN analysis included here is intended to provide a high-level assessment and therefore relies on several simplifying assumptions. TENs generally provide the greatest benefits in districts with diverse heating and cooling load profiles, where simultaneous heating and cooling enable heat sharing between buildings, and reduce the need for heat pump operation. Accordingly, this analysis focuses on medium-density, mixed-use districts, which are assumed to offer greater peak demand reduction potential. However, while the presence of commercial buildings is assumed to create the load diversity that benefits TEN performance, the analysis does not explicitly model the energy use or load profiles of those commercial buildings. Instead, it quantifies only the efficiency improvements and peak demand reductions realized by the residential buildings connected to the network. In addition, because published performance data for TENs remains limited, the analysis evaluates a range of network COP values based on the best available literature rather than relying on a single representative value.

Endnotes

¹ LaBella Associates, *New York City Health + Hospitals/Kings County Hospital North Campus District Geothermal System: Final Report*, New York State Energy Research and Development Authority, September 2024

² Ravi Gorthala, *Thermal Energy Networks: Technical, Economic, and Environmental Analysis*, 2024, <https://portal.ct.gov/-/media/deep/energy/ulbrich-geothermal/tech-econ-env-report-8-final.pdf>

³ *Case Study: Framingham, Massachusetts*, Building Decarbonization Coalition, Accessed July 2026, <https://buildingdecarb.org/resource/case-study-framingham-massachusetts>