How Thermal Energy Networks Are Key to Successful Electrification

Harnessing, moving, and sharing the heat we already have can help us electrify our buildings efficiently, affordably, and reliably.

Decarbonizing Vermont's buildings is essential to achieving our climate goals.

To meet our state-mandated emissions reduction targets, we need to heat and cool buildings without using fossil fuels. Electrifying our heating systems has been identified as a core strategy to reduce greenhouse gas emissions. As widespread electrification will increase the demand on our electrical infrastructure, keeping electric heating as efficient as possible is critical to reducing the impact of significantly greater electric use.

Thermal Energy Networks can help lower demand on the electric grid and avoid over-building costly electricity infrastructure, making electrifying heating and cooling more affordable and reliable for everyone.

Ground Source Heat Pumps and Electric Use

Thermal Energy Networks use Ground Source Heat Pumps (GSHPs) and underground pipes to supply highly efficient heating, cooling, and domestic hot water.

GSHPs function like Air Source Heat Pumps (ASHPs), but rather than drawing warmth from the air outside, they use stable temperatures from underground or waste heat extracted from large commercial buildings, refrigeration, and wastewater systems. Like ASHPs, GSHPs use electricity to extract and move heat to deliver both heating and cooling. However, because GSHPs use more constant temperature sources, they are highly efficient and require much less electricity.

GSHPs balance energy loads and reduce peak electric demand by:

- Using less electricity than other technologies.[1]
- Minimizing power drawn from the electric grid when paired with solar to provide the electricity needed to run the system.
- Allowing more electric grid capacity to be used for transportation and other decarbonization strategies beyond heating and cooling.
- Sending excess heat into the ground to store for later use.

When networked, GSHPs deliver even more benefits to the electric grid. Sharing thermal resources between buildings with different thermal needs means that less electricity is needed to provide the same amount of heating and cooling as an individual GSHP or ASHP. For example, a large grocery store with year-round refrigeration needs can create "free heat" for nearby buildings to use in the winter.

Understanding the Falcon Curve

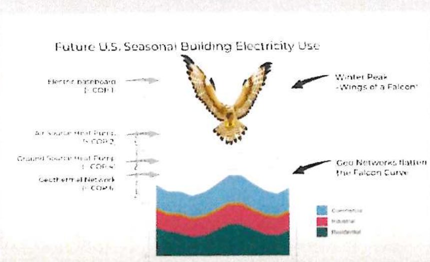

Image courtesy of heet

Using electricity for heating and cooling creates significant winter and summer demands—or peaks—that drive up costs and present energy system reliability challenges.

As we replace more gas, oil, and propane heating with electric systems, we'll increase those winter peaks. As the climate warms and we need to cool more buildings more often, we'll also create higher summer peaks.

The "Falcon Curve"[2] describes the seasonal increases that can result from electrifying heating and adding more cooling.

The graph models how energy peaks are influenced by different technologies, from electric baseboard heating (highest peaks) to geothermal networks (lowest peaks).

Among building electrification strategies, GSHPs and geothermal networks perform best at minimizing peak demand.

In colder climates, researchers expect winter peaks to be even higher than national averages, making flattening this curve even more essential.

GSHPs Lower Electric Rates and Increase Affordability

Our electric system needs to be able to supply electricity whenever we need it, including at "peak" times. This means that we need to build a system which meets this "worst case" condition. Electric rates are determined by the difference between how much energy we use overall and peak demand on that system. Generally, a higher curve means higher rates and more expensive electric bills. The more we can lower peaks and the less electric infrastructure we have to build, the more affordable our electricity will be.

GSHPs are a key tactic to add to our strategy for successful electrification.

How do we know GSHPs can play a significant role in electrifying buildings?

A recent analysis of electrification strategies across Canada found that including GSHPs reduces the overall cost of electrification, particularly in more northern regions. The report by Dunsky Energy Consulting concluded that:

> *"While GSHPs will cost more upfront to install, the peak load and electric consumption benefits will often more than offset this additional cost."*
>
> *"GSHPs can provide significant benefits by electrifying space heating with much lower peak load impacts – especially in colder climates."*
>
> *"GSHPs can reduce the need to invest in expanded electricity infrastructure by a greater amount, leading to overall cost reductions."*[3]

Overall, the report found that "inclusion of GSHPs (in lieu of ASHPs) could theoretically cut an additional $357 billion from the price tag"[4] of electrification across Canada.

How can Thermal Energy Networks and GSHPs help us achieve a successful energy transition in Vermont?

Much of our electricity in Vermont is produced out of state. Thermal Energy Networks and GSHPs can reduce our need for importing energy and help us be more independent from fluctuating energy costs and markets. We can have more local energy, increasing reliability and resilience.

As we build more solar and other forms of clean electricity in Vermont, we can also add GSHPs in our buildings to reduce electric demand and more easily achieve our electrification goals.

As long as our electric supply continues to rely on sources that aren't renewable, adding more GSHPs in Vermont will help us reduce our use of electricity that isn't as clean as we need or want it to be.

Thermal Energy Networks and GSHPs will not be the best solution for every location in Vermont, but by installing and networking them where we can—in town centers and neighborhoods across the state—we can accelerate our emissions reductions, make energy more affordable, and contribute to a successful energy transition.

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[1] "The EPA reports that GSHP systems are 44 percent more efficient than air source heat pumps and up to 72 percent more efficient than electric resistance heating with standard air-conditioning equipment." https://www.cesa.org/wp-content/uploads/A-Vermonters-Guide-to-Residential-Clean-Heating-and-Cooling.pdf

[2] Buonocore, J.J., Salimifard, P., Magavi, Z. et al. Inefficient Building Electrification Will Require Massive Buildout of Renewable Energy and Seasonal Energy Storage. Sci Rep 12, 11931 (2022). https://www.nature.com/articles/s41598-022-15628-2

[3] Dunsky Energy Consulting. Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), 2020, The Economic Value of Ground Source Heat Pumps for Beneficial Electrification. Pages 10-11. https://www.hrai.ca/uploads/userfiles/files/Dunsky__HRAI_Benefits%20of%20GSHPs_(2020-10-30)_F.PDF

[4] Ibid. Page v.