Smart, Tunable Thermal Energy Storage (TES) as an Enabler for Decarbonized Buildings

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Introduction
The rapid development of renewable energy sources requires flexible building HVAC technologies to alleviate the stress on the electric grid. Peak air conditioning loads stress the grid in July/August today, and peak Heat Pump loads in January/February will stress the grid in the future.
This study focuses on using multi-source heat pumps integrated with novel, tunable TES to shift loads from peak to off-peak, to improve efficiency, and to absorb abundant/inexpensive renewable power.

Methods
Building Load Generator
Heat Pump Model
MicroEra’s Tunable TES

The Energyplus model of Syracuse Center of Excellence was developed to generate the air-side load demand. Then a hybrid heat pump (ground-source, air-source) was modeled and integrated with MicroEra Power’s tunable Thermal Energy Storage (TES) system to evaluate the energy saving and load shifting potential.

Results
The proposed multi-source heat pumps have a high COP when sourcing from the ground loop, especially during extreme winter or summer weather. This results in energy savings of an estimated 28% for both cooling and heating compared to air source heat pumps. At off-peak times, the TES can be charged with low-cost electricity, and at later peak times, supplies the needed heat or cooling. The price differential for peak vs. off-peak electricity resulted in a 37% reduction in cooling costs and 59% reduction in heating costs. And the peak HVAC load for the Syracuse COE building case study can be reduced by 60% with 2 x 1500 gallons TES tanks.

Conclusion
• Nearly 30% energy consumption can be reduced by ground source heat pump.
• Up to 60% of the peak load can be reduced by integration with two thermal tanks.
• 32.8% to 73.8% cost savings during the cooling season with different tank capacities.
• 20.3% to 43.4% cost savings during the heating season with different tank capacities.
• 23 to 75$ daily cost saving on average.
• 1400 to 4500$ total savings in a two-month evaluation.

Impact
Traditional Geothermal HVAC often has extremely long payback due to the very high cost of drilling the ground loop. Urban applications tend to also be space constrained. A geothermal hybrid system, leveraging MicroEra Power’s tunable TES can contribute to efficient, flexible and grid-responsive operation, with downsized ground loop, resulting in an affordable capital cost.

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