INVESTIGATION OF THERMAL ENERGY STORAGE-HEAT PUMP INTEGRATION FOR RESIDENTIAL APPLICATIONS

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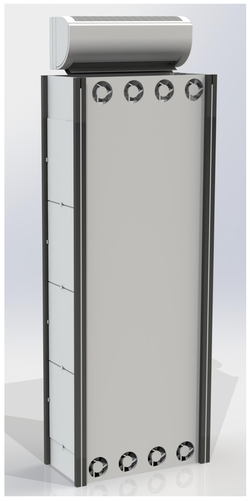
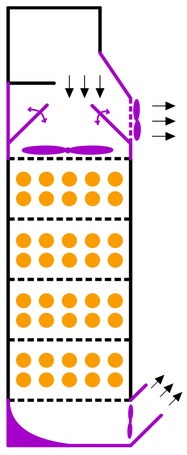
PHASE CHANGE MATERIALS & CABINET DESIGN

- Phase change materials are materials that releases and absorbs energy when they change phase, proving useful for heating and cooling applications
- PCM will be encapsulated in a bank of tubes fitted in a cabinet underneath the mini-split.
- Calculations determined 27 Gallons of PCM required
- Air will be forced through the banking to melt and freeze the PCM, when applicable.
- Modular design chosen to work with various mini-split.





ADAPTABLE CLEAN ENERGY (ACE) LAB

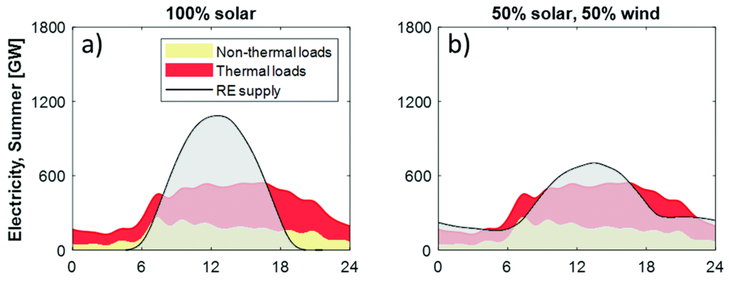
- Modular design is required that is compatible with a mini-split system.
- The Adaptable Clean Energy (ACE) Lab is a small scaled, self-sustaining Lab with a mini-split, completely removed the electrical grid.

BACKGROUND

Amidst escalating global warming concerns, the imperative to cut greenhouse gas emissions takes center stage in engineering research. Buildings, responsible for 10% of global greenhouse gas emissions and consuming 75% of grid electricity, pose a substantial challenge. As renewable energy integration surges on the grid, the need for energy storage intensifies. While large-scale battery storage seems intuitive, its cost and scale render it a problematic sole solution. Given buildings' significant electricity demand, local energy storage is commonplace, with a substantial share of that demand stemming from thermal loads like space conditioning and refrigeration. There is a mismatch between future energy supply profiles and building load requirements, with the primary energy needs being thermal in nature, making thermal energy storage (TES) a well-suited, potentially cost-effective, and longer-lasting alternative to electrical batteries.

LOAD SHIFTING

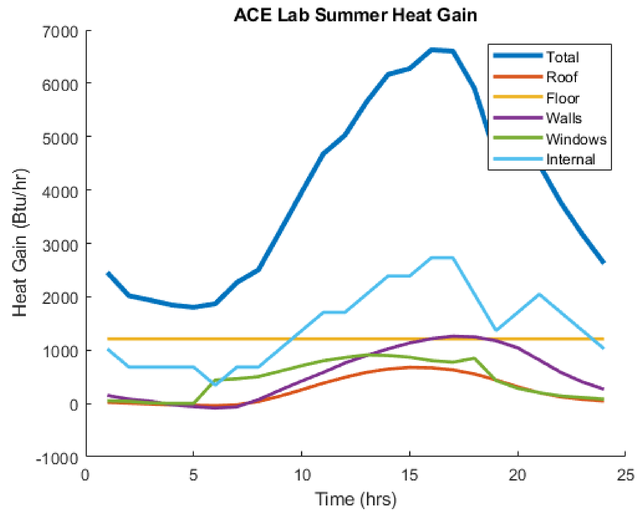
- The primary purpose of TES is to shift energy usage from peak hours to off peak hours.
- Renewable energy (RE) is inherently intermittent, meaning TES would allow for heating and cooling when renewable energy isn't required.
- Shitting to off-peak hours also allow for cheaper energy costs, if still connected to the electric grid.



Odukomaiya A., et al. Addressing energy storage needs at lower cost via on-site thermal energy storage in buildings, Eng. & Envr. Sci (2021)

SUPPORTING ANALYSIS & DATA COLLECTION

- The ACE Lab was instrumented to determine key data points for the system to become feasible.
- The temperature of the air coming from the mini-split was determined to be between 5-10 °C.
- The PCM selected was PureTemp 20, based off instrumented data
  - Changes phase from liquid to solid and vice versa at 20 °C
  - Above air supply temperatures
  - Below ambient temperatures
- Calculations determined 27 Gallons of PCM required based off the heat gain during summer months about a 4-hour period



DESIGN REQUIREMENTS

- Based on the energy flows of the ACE Lab, when excess energy is available the system shall begin to charge the TES
- TES shall be discharged during the day to flatten the required cooling loads during the day.
- System shall remain in functioning order for at least 10 years.
- TES System shall keep comfortable temperature in the ACE Lab for 4 hours at ASHRAE standards
- An external power supply shall be added to the system to force air over the TES for 4 hours without power gird dependency.
- The system shall be able to withstand a point load of 150 lbf without causing harm to the unit or person.