Load-based performance evaluation of a phase change thermal energy storage system

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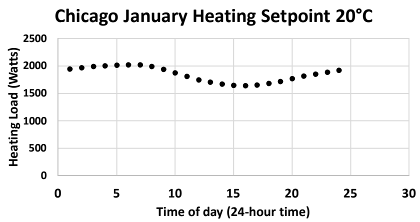
Introduction

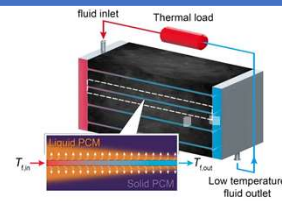
- Commercial buildings comprise 40% of US energy consumption
- 35% of building energy is used for heating, ventilation, and air conditioning (HVAC)
- Renewable energy sources are intermittent, making renewable penetration difficult
- Thermal energy storage (TES) works as a "thermal battery" and can be used to shift peak loads

Load Profile Calculation

- Using EnergyPlus and OpenStudio, we obtained a room load profile for a heating end use case
- The profile used weather data from January in Chicago, Illinois, assuming a 20°C heating setpoint



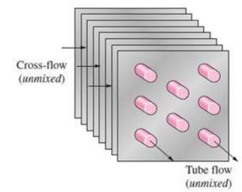
Thermal Energy Storage (TES)



- A phase change material (PCM) stores/releases thermal energy through phase transitions
- The PCM solidifies as it adds heat to the working fluid
- We used an existing 2-D finite-volume PCM heat exchanger model

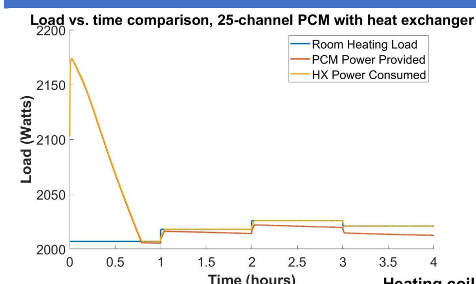
Heat Exchanger Sizing

- A heat exchanger exchanges heat between two working fluids
- We used a crossflow heat exchanger as our heating coil model

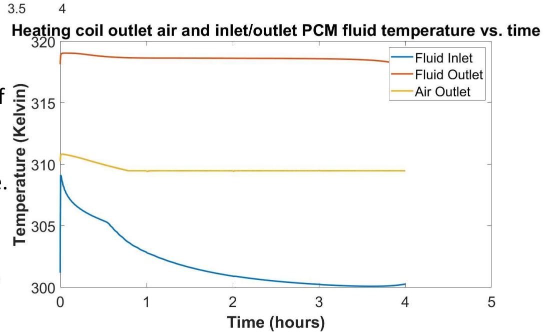


- The heating coil was sized using sample temperature data and was integrated with the PCM heat exchanger model

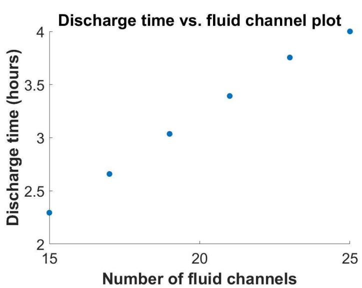
Results



Left: a plot of the PCM, heating coil, and room loads as a function of simulation time. The steps in values correspond to the dynamic load changing each hour.



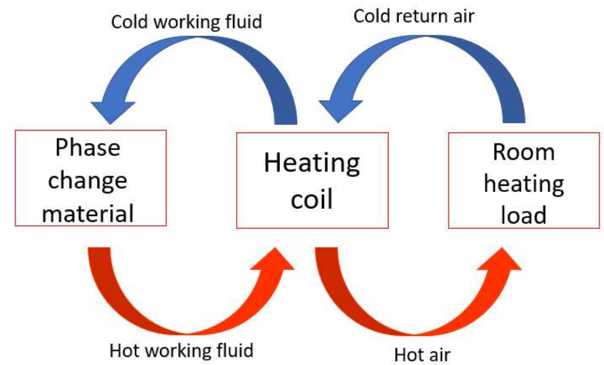
Right: the outlet air temperature of the heating coil, and the inlet and outlet PCM fluid temperatures plotted against the simulation time.



Left: a plot of the discharge time against the number of fluid channels in the PCM. The cutoff criteria for the discharge time is the point at which the PCM load and the room load differ by more than 15 Watts.

Discussion, Conclusions, and Future Work

Our model can be used to evaluate TES systems using a dynamic load profile and to investigate the effects of different heat exchanger design parameters.



Further work:

- Optimizing design of PCM heat exchanger for heating use cases
- Using a more realistic building model as opposed to a single room
- Considering other end use cases, such as cooling or refrigeration

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