ET Summit 2022

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Advanced Heat Pumps Plus Thermal Battery Provide Demand Flexible, Efficient, and Cost-Effective Comfort All Year

Update on the DOE BTO Project

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EPRI 50th ANNIVERSARY

DOE Project Objectives

Develop, demonstrate, measure and verify the performance of a Dual-Purpose (Heating & Cooling) Thermal Battery Heat Pump System:

- Provide heating and cooling at high efficiency, particularly during extreme weather conditions
- Thermal battery used as heat reservoir to absorb heat in cooling mode and reject heat in heating mode
- Provide flexibility to shift load from peak hours to off-peak hours

Project Objectives

- Develop and validate a single integrated 5 Ton heat pump-thermal storage system that can operate in both cooling and heating modes

Metric	Target
(Commercial) System Capacity	5 tons
Demand Reduction	>50 %
Period	>4 hours
Overall COP improvement	>20 %
TES cost	<15 $/kWh

- Year **1** Component and System Design, Prototyping, and Component Testing
- Year **2** Full-Scale System Construction and Laboratory Testing
- Year **3** Field Testing and Validation; Next Steps toward Commercialization

Period of Performance: Q1 2022 to Q4 2024

DOE Project Partners

- Project based on a U.S. Dept. of Energy award to University of Maryland

BUILDINGS ENERGY EFFICIENCY FRONTIERS & INNOVATION TECHNOLOGIES (BENEFIT) – 2020

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — *National Energy Technology Lab*

Prime Recipient: CENTER FOR ENVIRONMENTAL ENERGY ENGINEERING

Sub-Recipient: EPRI ELECTRIC POWER RESEARCH INSTITUTE

- Other Project Members

Rheem

Heat Transfer Technologies

INSOLCORP

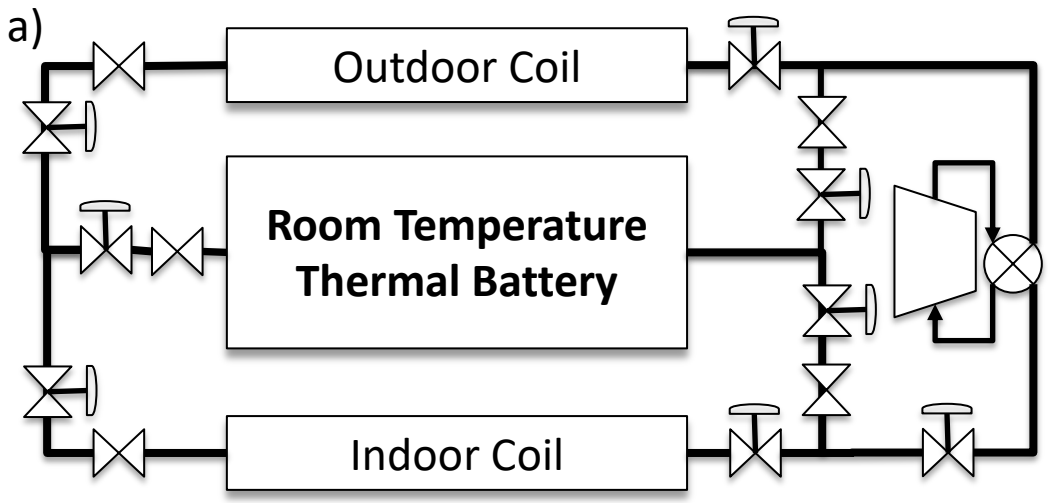
OAK RIDGE National Laboratory

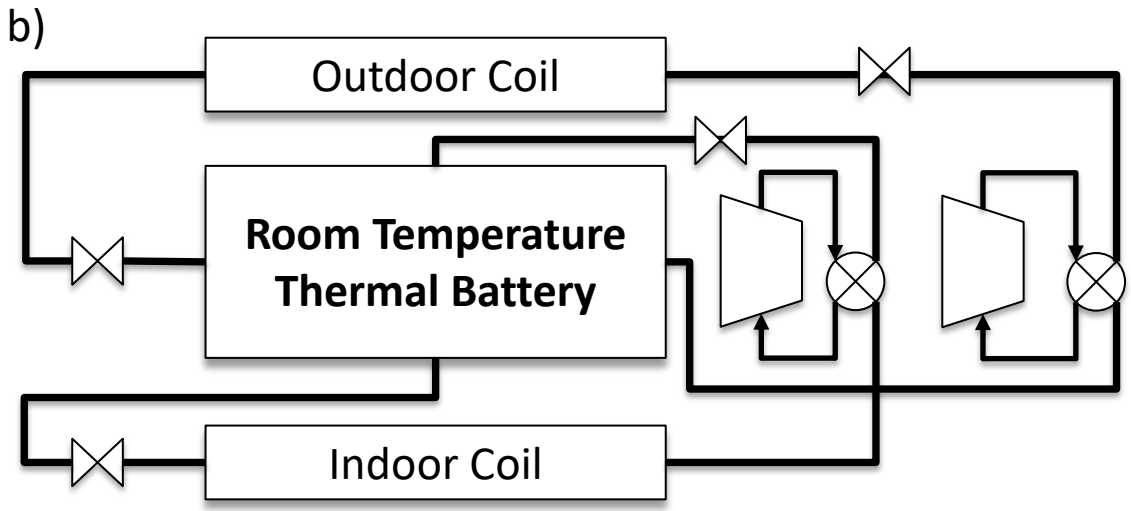
SOUTHERN CALIFORNIA EDISON — Energy for What's Ahead™

Powerful Team!

Technology Description

- Dual-purpose (heating and cooling) thermal battery with room temperature storage integrated with heat pump(s) (HP's) for commercial applications
- The battery serves as the heat reservoir that absorbs heat when operating as condenser in cooling mode or rejects heat when operating as evaporator in heating mode
- The system may be configured as a single HP with one compressor (preferably two-stage), or two separate HPs with dedicated compressors





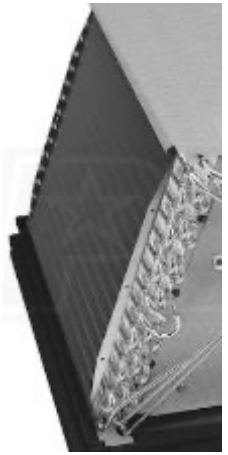
Some HX Geometries Suitable for TES

- **The HX below are suggested for use in a PCM-embedded HX TES system for the following desired properties:**
- **Low-cost**
- **HX occupies small volume**
- **Compatibility with Insolcorp storage material**

1. Wire HX:
Steel tube with steel wires on both sides of the tubes.

2. Serpentine tube dogbone fin HX:
Low-cost, wide fin spacing (no enhancements), continuous tube (no leakage potential)

3. Aluminum microchannel / serpentine fin HX:
The fin density will probably need to be lowered. This configuration makes for a very effective HX.



4. A/C evaporator coil:
This tube and fin "traditional" type design is common in A/C evaporator coils. Geometry (tube spacing/rows, fin density) will require optimization for use in thermal storage device.

Budget Period 1 - Status

- **Milestone 1.1 (Complete)**
  - Baseline modeled and validated against rated and test data
- **Milestone 1.2 (Complete)**
  - COP improvement marginally increases for UA>9000BTU/hr.°F
  - Demand reduction greater in the winter and more sensitive for more extreme climates (all US climate zones investigated)
  - Demand reduction in the Summer affected by compressor efficiency degradation (15-20%) → use two-stage compressor or two separate compressor sizes
  - Unable to achieve 50% demand reduction all year round → possibly focusing on one season, but still achieving some reduction all year round
- **Milestone 1.3 (In Progress)**
  - PCM properties characterization underway
  - Material compatibility tests underway
  - Storage (Compactness ~ 500m^2/m^3) and performance (HTC ~ 200$W/m^2.K$) requirements can be achieved using conventional (lower cost) geometries
- **Milestone 1.7 (In Progress)**
  - Field-test site selection and coordination in progress

Summary

- TES materials and Heat Exchanger geometries are the key
- TES materials need to be designed for cooling or heating, not both
- Need to reduce the weight of the thermal battery

- Challenging project – Please stay tuned

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