

ORNL Building Technologies Program Highlights for the 2024 Stor4Build Annual Meeting

Melissa Lapsa, Buildings Program Director

August 26, 2024

ORNL is managed by UT-Battelle LLC for the US Department of Energy

DOE National Blueprint for Buildings Sector – Decarbonizing the U.S. Economy by 2050



Reduce U.S. building emissions 65% by 2035 and 90% by 2050 vs. 2005 while enabling net-zero emissions economy wide and centering equity and benefits to communities

CROSS-CUTTING GOALS



Equity – Advance energy justice and benefits to disadvantaged communities

Affordability – Reduce energy burden and technology costs so all can benefit

Resilience – Increase the ability of communities to withstand and recover from stresses

STRATEGIC OBJECTIVES



Increase building energy efficiency

Reduce on-site energy use intensity in buildings 35% by 2035 and 50% by 2050 vs. 2005



Accelerate on-site emissions reductions

Reduce on-site GHG emissions in buildings 25% by 2035 and 75% by 2050 vs. 2005



Transform the grid edge

Reduce electrical infrastructure costs by tripling demand flexibility potential by 2050 vs. 2020



Minimize embodied life cycle emissions

Reduce embodied emissions from building materials and construction 90% by 2050 vs. 2005

Approach to Affordable Housing*

*single-family, multifamily, and manufactured homes occupied by households earning <80% of the area median income



The Energy Earthshot focuses on the challenges facing the 50M homes that make up the U.S. affordable housing stock.



Focus on multifamily and manufactured homes

Over 60% of multifamily and manufactured buildings serve as affordable housing and face unique decarbonization and affordability challenges.



Create scalable solutions that minimize disruptions to renters

Over 58% of low-to-moderate income households are renters.



Target design barriers specific to older buildings

Affordable housing is more likely to lack adequate insulation and central AC, as well as experience other non-energy hazards such as lead and mold.

Lead Target

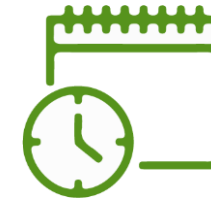
Reduce by 50%+ the cost of retrofit packages needed to decarbonize affordable housing while lowering energy bills by 20% within a decade.



50% lower
upfront cost



20% lower
energy bills



Within a
decade



BUILDING UPGRADES

Improved livability and comfort make homes more resilient.

Advanced leakage detection

Low-impact retrofit techniques

Panelized exterior insulation



EFFICIENT ELECTRIFICATION

Innovations that streamline systems and lower costs enable affordable and adaptable installation.

Lower-voltage equipment

Plug-and-play heat pump designs

Integrated ventilation packages



SMART CONTROLS

Flexible energy loads transform homes into energy resources.

Smart electric panels and load management

Grid-interactive technologies

Shared circuit control between loads

BUILDING TECHNOLOGIES RESEARCH
AND INTEGRATION CENTER

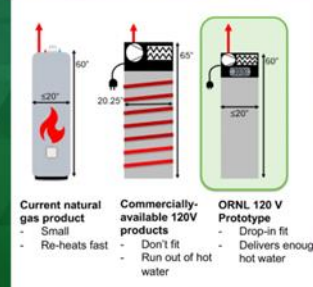
120V Heat Pump Water Heater

USES ULTRA LOW GWP
REFRIGERANT (R290)

- Latest prototype has 82% refrigerant charge reduction vs. state of art commercial unit
- Low impact of heat exchanger fouling due to design
- Maintains 2–4 times the Uniform Energy Factor compared to traditional water heating methods (e.g. gas and electric storage water heaters)
- Meets or exceeds Energy Star requirements

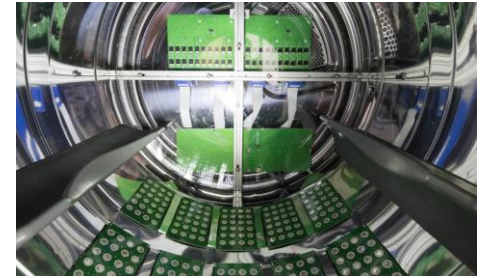
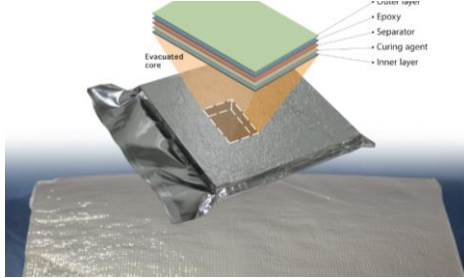
120V HPWH REPLACEMENT SOLUTION

- ORNL is influencing the market by:
- Using advanced modeling tools for system design
 - Prototyping the system and disseminating results
 - Partnering with industry to design for manufacturability and cost



OAK RIDGE
National Laboratory

Accelerating affordable building energy efficiency solutions



Buildings-to-Grid

Advanced wireless sensor technologies

Building energy modeling

Communications & controls

Energy-optimized solutions for connected communities

Building Envelopes & ABC

New & emerging materials, components & systems

Advanced building construction

Fundamental science of heat, air & moisture transfer for walls, attics, foundations, sheathings, membranes & coatings

Energy Storage/Multi-functional products

Integrating advanced energy storage in equipment & envelope systems, flexible building loads, dynamic facades & thermal energy storage materials

Systems Integration

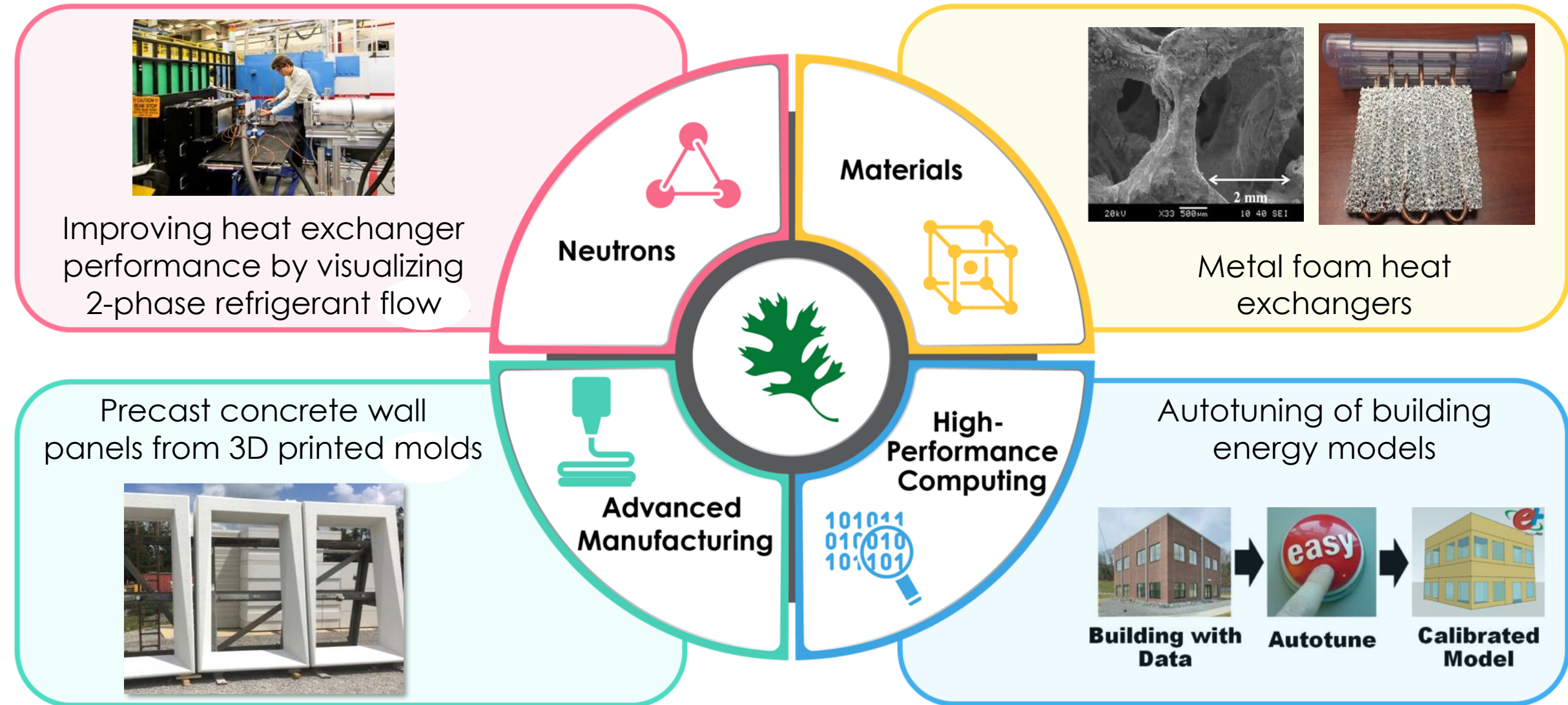
Testing new components, equipment & systems in realistic environments before market introduction

Research house with simulated occupancy, light commercial flexible building research platforms & computer modeling, visualization & analytics

Energy-Efficient Equipment

Helping industry launch some of the most energy-efficient building equipment technologies on the market for a wide range of applications

ORNL brings science signature strengths that can be leveraged by individual projects



BTRIC By the Numbers



128 staff members as of FY24



64 CRADAs, **9** SPPs, and **4** User Agreements active in FY24



20+ student interns for FY24



5,306+ BTRIC visitors since 2012



16 R&D100 awards since 1992
36 ASHRAE awards since 1982



116 invention disclosures, **38** patent applications, **18** granted patents, **5** licenses since 2021



6,000+ experts at ORNL with diverse backgrounds and experience



140+ Industry Partners, **60+** University Partners across FY23-FY24



139 publications for FY24



60,000+ sq. ft. facility space

In FY24 BTRIC Collaborated with Industry Partners through 77 CRADAs, SPPs, and User Agreements:



Case Study

Self-healing Elastomers

ORNL researchers used a blend of a self-healing polymer with curable elastomers to produce a series of self-healable and highly adhesive materials. The team proved that these elastomers can self-repair in ambient temperatures and conditions and underwater as well, with their adhesive force minimally impacted by surface dust. The elastomers demonstrated unprecedented adhesion strength and the ability to adhere to many surfaces, which could broaden their potential use in industrial applications.

Case Study

Domino Sugar

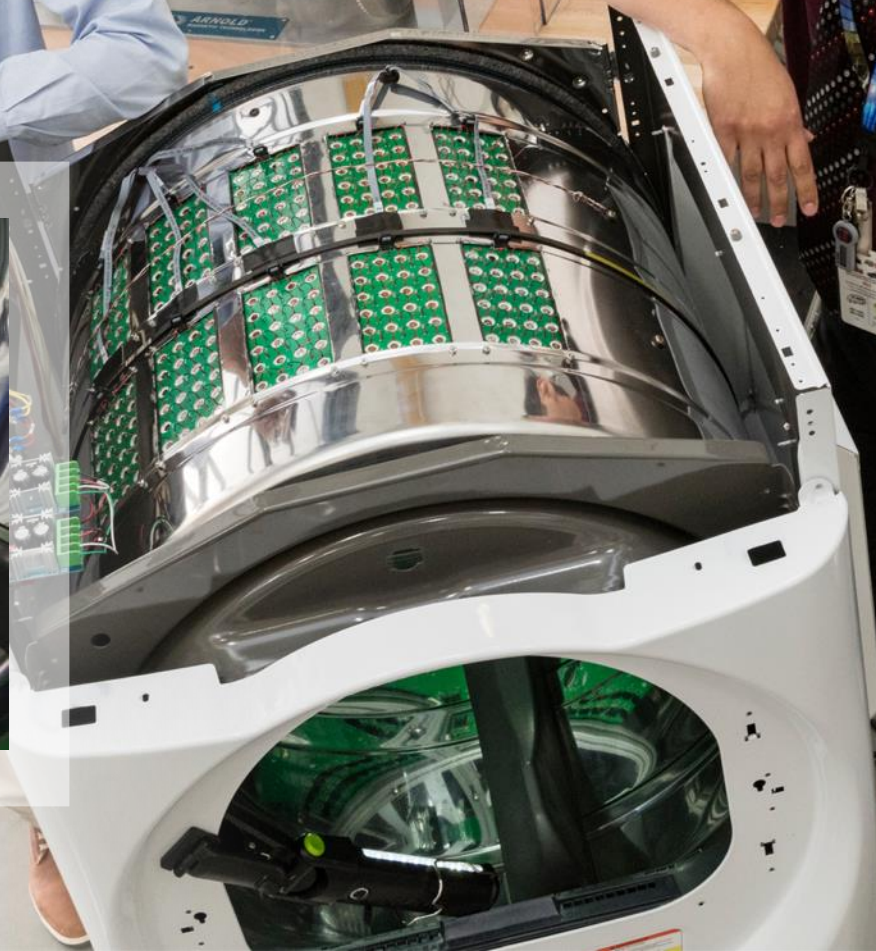
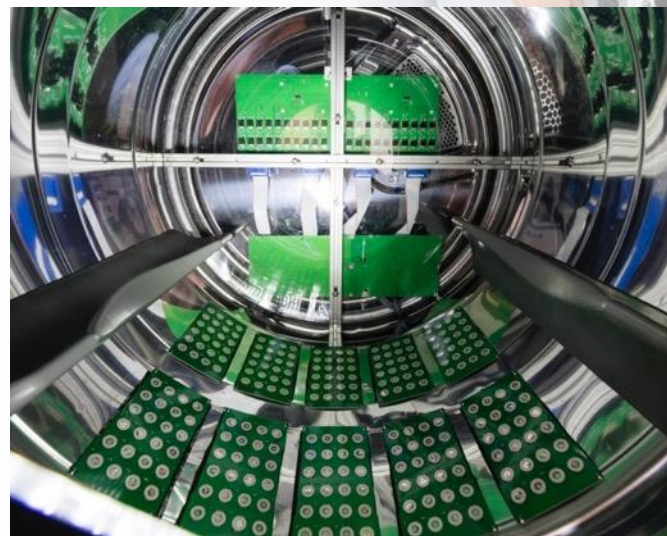
The Domino Sugar Refinery is the first building in the United States to use 3D printed molds to cast concrete. Not only does 3D printing yield highly replicable and long-lasting parts, but the process also generates less material waste, and the molds can be used upwards of 200 times, an order of magnitude more than traditional molds, which can typically only be used for about 15 to 20 concrete pours.



Case Study

Ultrasonic clothes dryer

ORNL has invented a new drying technology that uses piezoelectric transducers instead of heat to shake to vibrate fabric at a high frequency, resulting in moisture removal. Results in a faster drying time and uses 5X less energy than conventional dryers.



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2024 Stor4Build Annual Meeting

Review of Agenda and Intro to BTRIC Facility Tours

Kashif Nawaz, Section Head Buildings Technologies Research

August 26, 2024

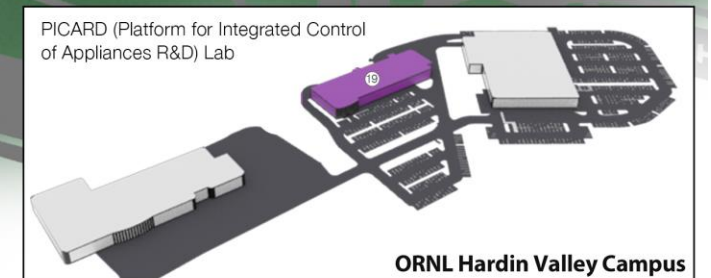
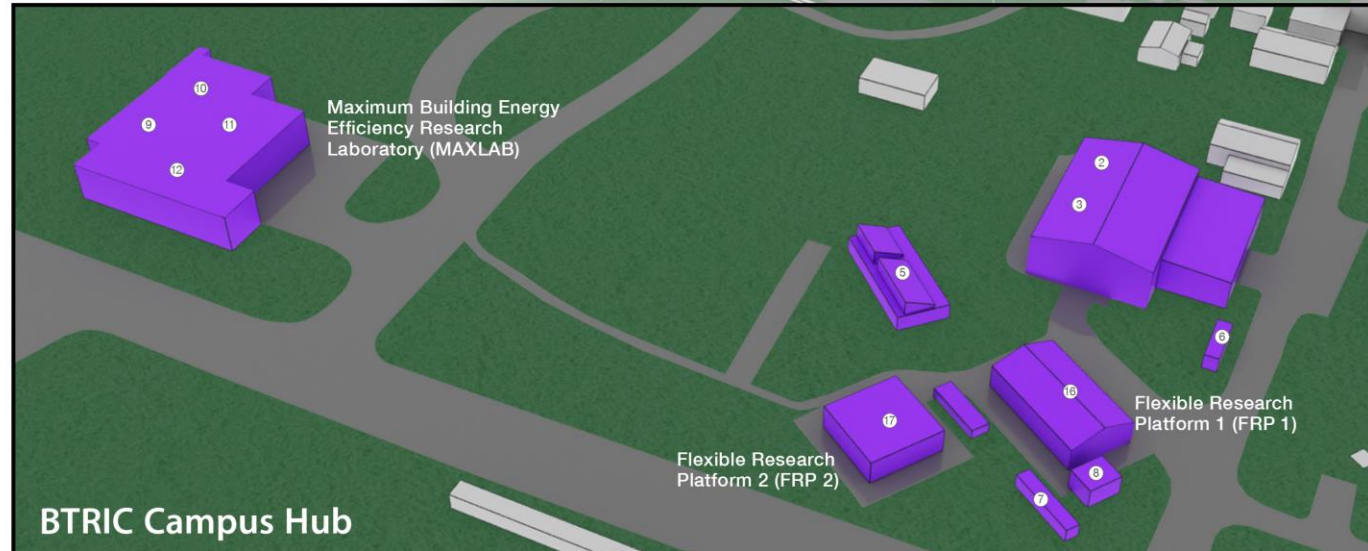
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Buildings Research Laboratory

● BTRIC Research Locations

1. Commercial Building Equipment Lab
2. Building Equipment Lab
3. Building Envelope Systems Lab
4. Residential Appliances Lab
5. Hygrothermal Lab
6. Envelope Test Structure
7. Ag Pod
8. High Temperature Heat Pump Test Facility
9. Maximum Building Energy Efficiency Research Laboratory (MAXLAB)
10. Multifunctional Equipment Lab
11. Advanced Construction Lab
12. Visualization Room
13. Sustainable Materials Lab
14. Alternative Refrigerants Lab
15. Thermal Energy Storage Lab
16. Flexible Research Platform 1 (FRP 1)
17. Flexible Research Platform 2 (FRP 2)
18. Building Equipment Lab
19. PICARD (Platform for Integrated Control of Appliances R&D) Lab
20. Yarnell Research House

ORNL main campus



TES facilities: materials to systems innovation

Distributed building thermal storage reduces the electricity infrastructure needed for decarbonization

Material preparation



Temperature and Humidity Controlled Glovebox



Ball mill



Vacuum Oven



Sonicator Bath



Shaker



Hot Plate

Material and component development and characterization

milligram-scale

gram-scale

kilogram-scale



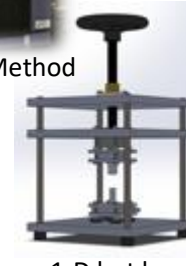
Differential Scanning Calorimeter



T-history Method



Neutron scattering



1-D hot bar



T-h "Tower"



ASTM Heat Flow Meter



ASTM Heat Flow Meter



Heat Exchanger Test Stands

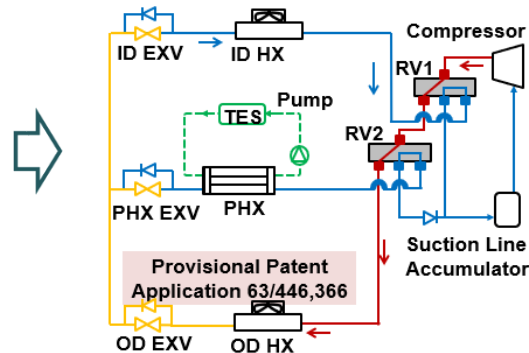


Heat exchanger design and fabrication



ORNL-developed PCM heat exchanger and low-cost salt hydrate PCM

Prototype development and evaluation



ORNL-developed TES-ready HP configuration enables peak demand shifting



RTU modified at ORNL for charging and discharging of TES

Prototype field evaluation



Yarnell Station unoccupied research home



Flexible Research Platform (FRP2) unoccupied

Review of Agenda

Time	Agenda
8:00 am	Registration / Breakout
9:00 am	ORNL BTRIC Welcome/Opening
9:15 am	Laboratory Tour
11:15 am	Poster Session
12:00 pm	ORNL Director Welcome/Opening
12:20 pm	Lunch & Networking
1:20 pm	Department of Energy and Stor4Build Leadership Welcome/Opening
2:00 pm	Plenary Session 1 – Pioneering Visions for the Future of Thermal Energy Storage
3: 40 pm	S4B project Update 1 - Advancing Controls in Thermal Energy Storage S4B project Update 2 – Incorporating Thermal Energy Storage Within Building Envelopes: Strategies and Benefits
4:50 pm	S4B project Update 3 – Advanced Modeling Techniques in Thermal Energy Storage S4B project Update 4 – Innovative Integration Strategies for Thermal Energy Storage with HVAC&R Systems
6:00 – 8:30 pm	Working Dinner @ Lakeside Traven (Transportation Provided)









Time	Agenda
8:00 am	Registration / Breakout
8:30 am	Plenary Session 2 - <i>Breaking Barriers: Market Transformation in Thermal Energy Storage</i>
9:40 am	S4B project Update 5 - <i>TES with HVAC in Today's Market</i> S4B project Update 6 – <i>Advancements in Materials for Thermal Energy Storage Systems</i>
10:40 am	Networking Coffee Break
11:00 am	Plenary Session 3 - <i>Critical Roles of Thermal Energy Storage Integration in Buildings and Building Equipment</i> Plenary Session 4 - <i>Unlocking Potential: TES Roles in Building Envelopes</i>
12:10 pm	Plenary Session 5 - <i>Insights from Utilities and Local/State Energy Offices: Programs and Perspectives on Thermal Energy Storage</i> Plenary Session 6 - <i>Addressing Market Adoption Challenges: Perspectives from OEMs and Thermal Energy Storage Manufacturers</i>
1:10 pm	Working Lunch & Networking
2:20 pm	S4B project Update 7 - <i>Advanced Thermal Energy Storage Solutions for Water Heating Systems</i> S4B project Update 8 – <i>TES with HVAC to Enable a Decarbonized Grid</i>
3: 30 pm	Task Force Group Introduction
4:00 pm	Wrap-up and Final Announcement
4:30 pm	Conference Adjourns and Transport to Hotel - Attendees
6:30 pm	Dinner on Own/Groups

Overview of Tour



- **Special Tours** **Group 1 (Super computer)** **Group 2 (Appliances lab)** **Group 3 (Refrigeration lab)**
 - **FRPs and MaxLab will be covered by all three groups**

Overview of Tour

		Stop 1	Stop 2	Stop 3	
Group 1	Conference center	Super-computer	Flexible Research Platforms	MaxTech Research Lab	Conference center
					
Group 2	Conference center	MaxTech Research Lab	Flexible Research Platforms	Appliances Lab	Conference center
					
Group 3	Conference center	Flexible Research Platforms	MaxTech Research Lab	Refrigeration Lab	Conference center
	