OAK RIDGE National Laboratory | BUILDING TECHNOLOGIES RESEARCH AND INTEGRATION CENTER

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Building Technologies Research and Integration Center Overview

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U.S. DEPARTMENT OF ENERGY

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FOR THE US DEPARTMENT OF ENERGY

BTRIC Campus and Research Priorities

Building Technologies Research and Integration Center (BTRIC)

SUPPORTS DOE'S BUILDING TECHNOLOGIES OFFICE

Only DOE-designated national user facility for buildings since 1993

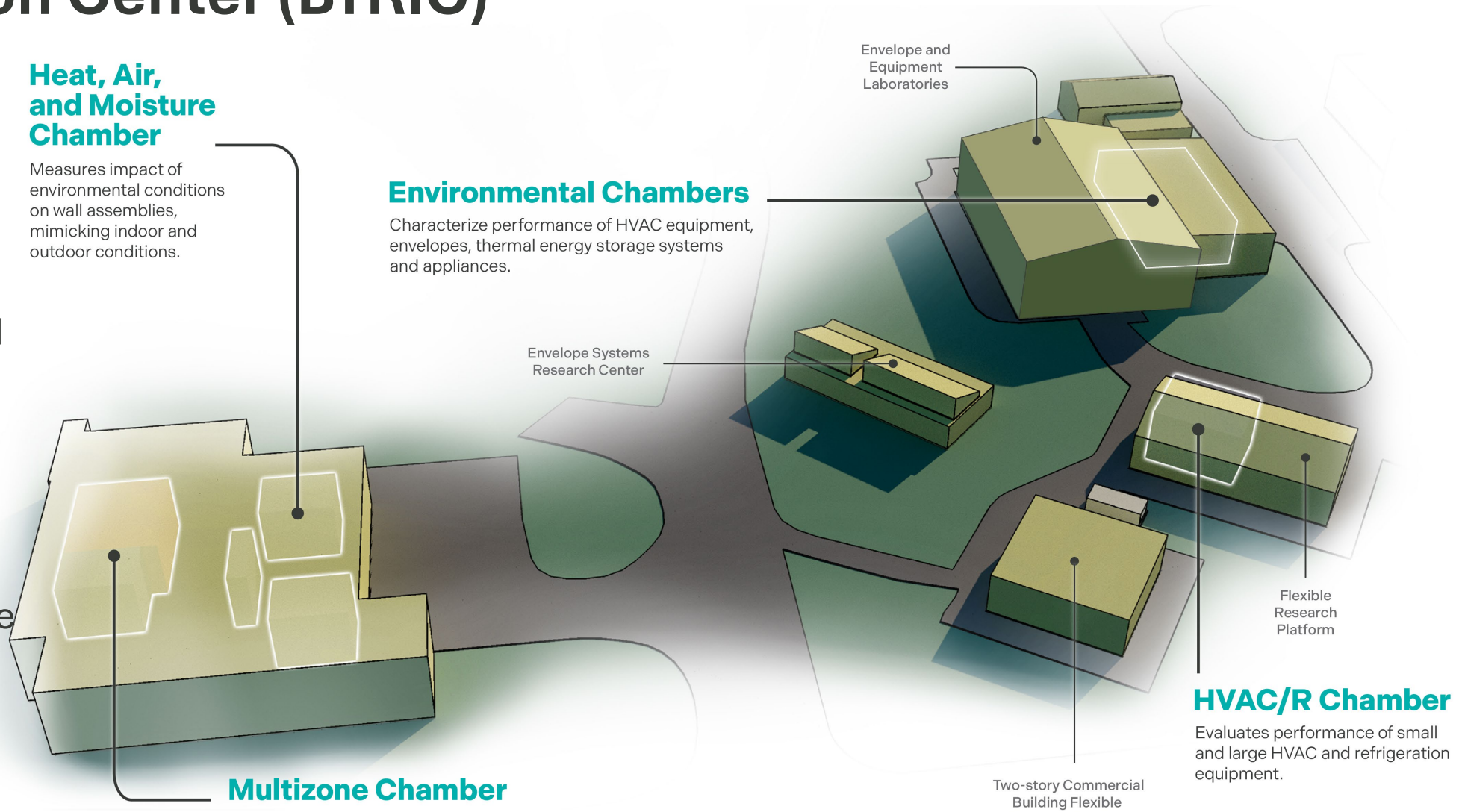
R&D focuses on developing innovative solutions for affordable and high-performing buildings

Heat, Air, and Moisture Chamber

Measures impact of environmental conditions on wall assemblies, mimicking indoor and outdoor conditions.

Environmental Chambers

Characterize performance of HVAC equipment, envelopes, thermal energy storage systems and appliances.



Multizone Chamber

Evaluates performance of residential and commercial equipment in different indoor and outdoor conditions.

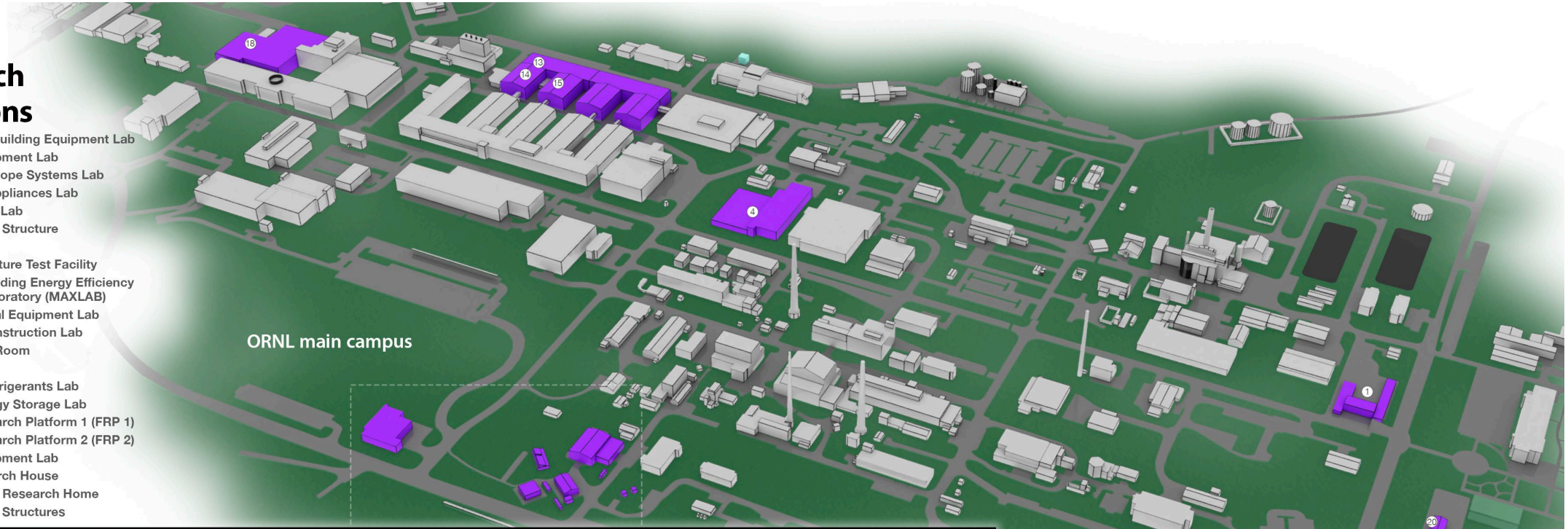
HVAC/R Chamber

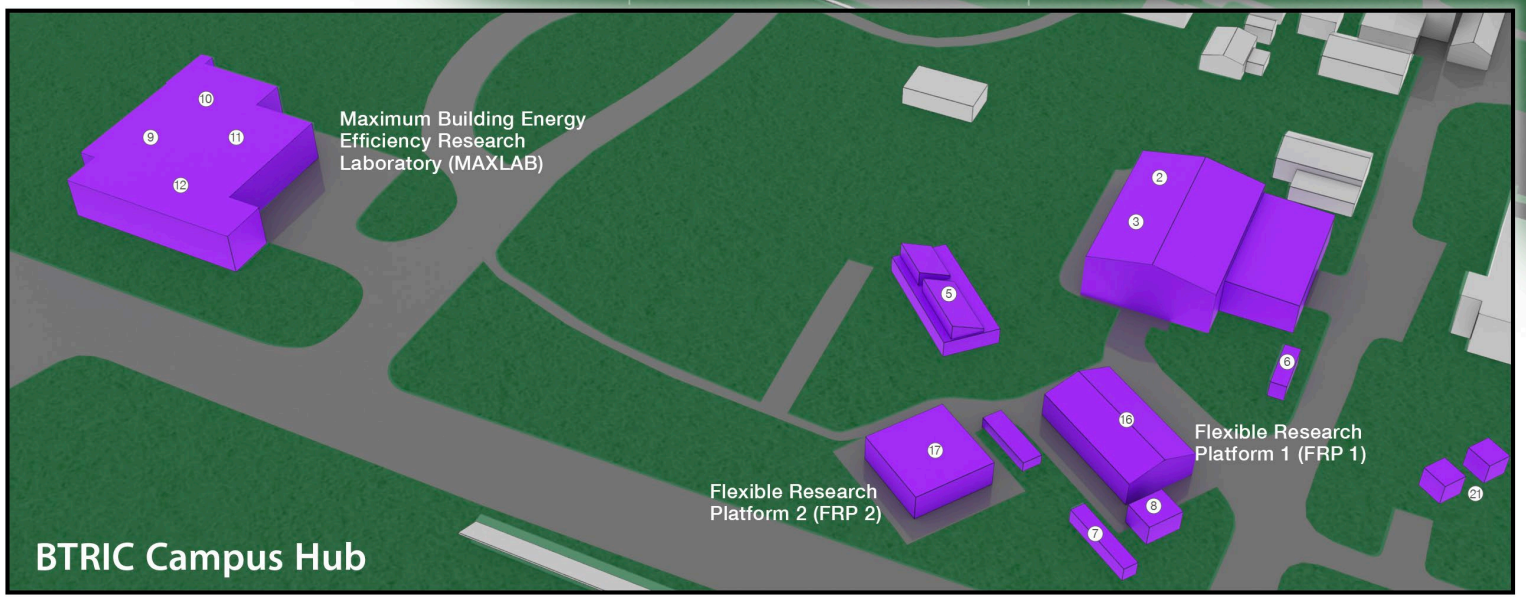
Evaluates performance of small and large HVAC and refrigeration equipment.

Buildings research campus has more than 30-year history

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. HVAC Lab
8. High Temperature Test Facility
9. Maximum Building Energy Efficiency Research Laboratory (MAXLAB)
10. Multifunctional Equipment Lab
11. Advanced Construction Lab
12. Visualization Room
13. Materials Lab
14. Advanced 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. Yarnell Research House
20. Manufactured Research Home
21. Envelope Test Structures





Accelerating affordable building system solutions

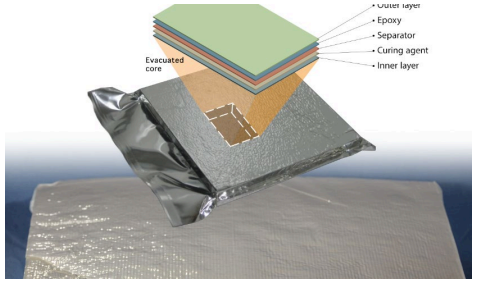
Buildings-to-grid

Advanced wireless sensor technologies

Building energy modeling

Communications and controls

Energy-optimized solutions at scale



Building envelopes and industrialized construction

New and emerging materials, components, and systems

Productivity, affordability, quality and safety in building construction

Durable walls, attics, and foundations

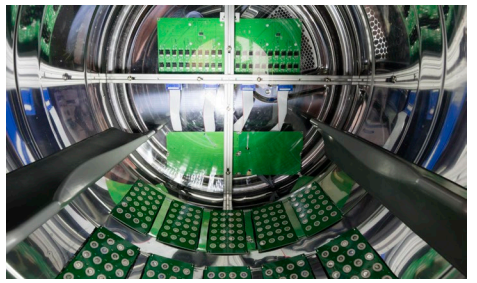
Energy storage/multi-functional products

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

Systems integration

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

Research house with simulated occupancy, light commercial flexible research platforms, computer modeling



High-performance equipment

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

BTRIC Impact

BTRIC by the numbers

134 staff members as of FY25

58 CRADAs, **8** SPPs, and **4** user agreements active in FY25

23 student interns for FY25

5,836+ BTRIC visitors since 2012

20 R&D 100 awards since 1992
40 ASHRAE awards since 1982

142 invention disclosures, **52** patent applications, **26** granted patents, and **11** licenses since 2021

7,400+ experts at ORNL with diverse backgrounds and experience

76 industry partners and **47** university partners in FY25

120 publications for FY25

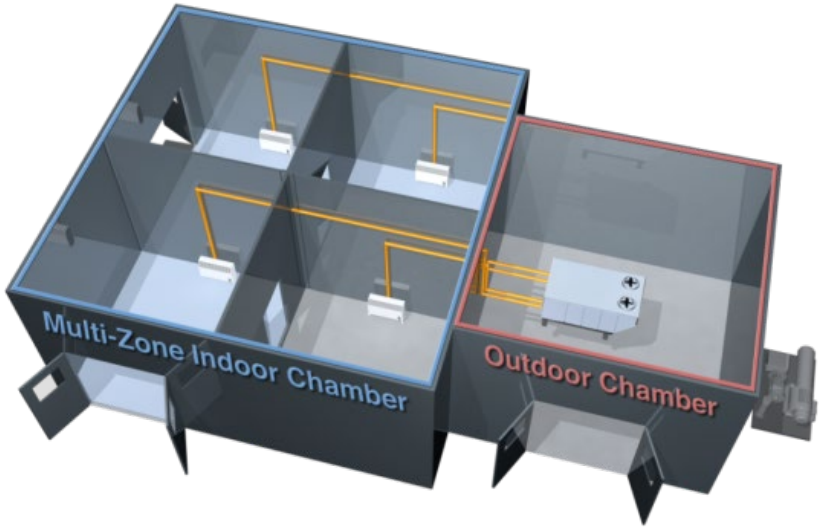
60,000+ sq. ft. facility space

FY25 industrial collaborations with 70 industry partners

Test Chambers and New Capabilities

BTRIC campus facilities

- Environmental chambers
- Refrigerant test loops
- High-temperature heat pump test beds
- Wind tunnels
- Controlled field test sites
- Real-world research house
- Flexible research platforms



ORNL building technologies chamber capabilities

Lab space	Year acquired	Chamber	Internal usable dimensions			Operational range		Flammable refrigerants testing (A2L and A3)*
			Length (ft)	Width (ft)	Height (ft)	Capacity	Temperature range	
New 2500 chambers	2025	ID	12	11	10	5 ton	50°F to 95°F	Yes
		OD	12	11	10	5 ton	-20°F to 95°F	Yes
2500 C1D2	2022		22	10	7.5	n/a	n/a	Yes
3144 15-ton equipment chambers	2025	ID	24	24	18	15 ton	32°F to 100°F	Yes
		OD	24	24	18	15 ton	-20°F to 135°F	Yes
3144 furnace venting chamber	2016		15	15	9	n/a	n/a	No
New 3144 stacked 25-ton equipment chambers	2026	ID	22	22	18	25 ton	32°F to 100°F	Yes
		OD	22	22	12	25 ton	-20°F to 135°F	Yes
3170A chambers	2018	ID	20	20	18	8 ton	32°F to 100°F	Yes
		OD	20	20	18	8 ton	-20°F to 130°F	Yes
4020 multi-zone chambers	2014	4 x ID	14	14	11	10 ton combined	-20°F to 120°F	Yes
		OD	20	15	11	13 ton	-20°F to 120°F	Yes
5800 large chambers	2005	ID	20	20	14	20 ton	5°F to 130°F	No
		OD	20	20	14	20 ton	5°F to 130°F	No
New 5800 appliance chamber	2024	-	7	7	8	3 ton	-31°F to 135°F	Yes

* Testing with flammable refrigerants is restricted by charge size (e.g., 150 grams/circuit for Class 3 refrigerants) and may require further mitigation actions, which are specific to the refrigerant type.

Multizone chamber

Capabilities

Four controlled sections for evaluating multiple types of equipment jointly operating at different conditions

20 ft x 15 ft outdoor and 28 ft x 28 ft indoor chambers

Dry-bulb temp -10°F to 130°F

Regulates relative humidity at levels of 30% to 90%

10 tons of capacity

Snow can be generated with precise condition control

Unique Characteristics

Only one of its kind in the United States

Capable of testing flammable refrigerants, advanced refrigerants, and performing risk assessment studies for refrigerant leaks

Partners – Industry/Other

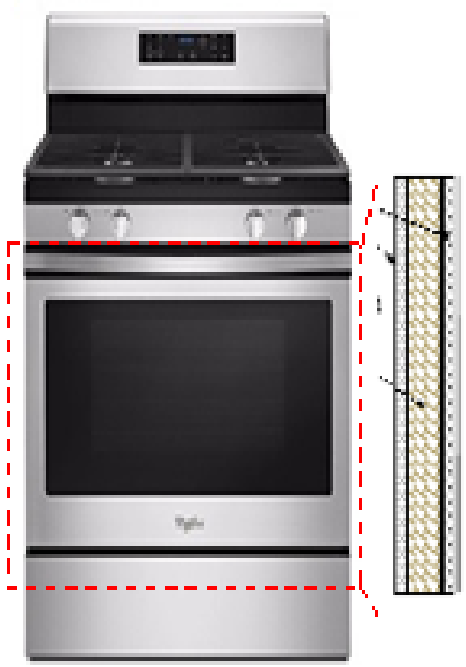
AHRTI, LENNOX, Johnson Controls, DAIKIN, Danfoss, Chemours, University of Maryland, Honeywell, Carrier turn to the experts, UNEP, EMERSON, NORTEK GLOBAL HVAC, The Unico System, TRANE It's Hard To Stop A Trane

Building electric appliances, devices, and systems

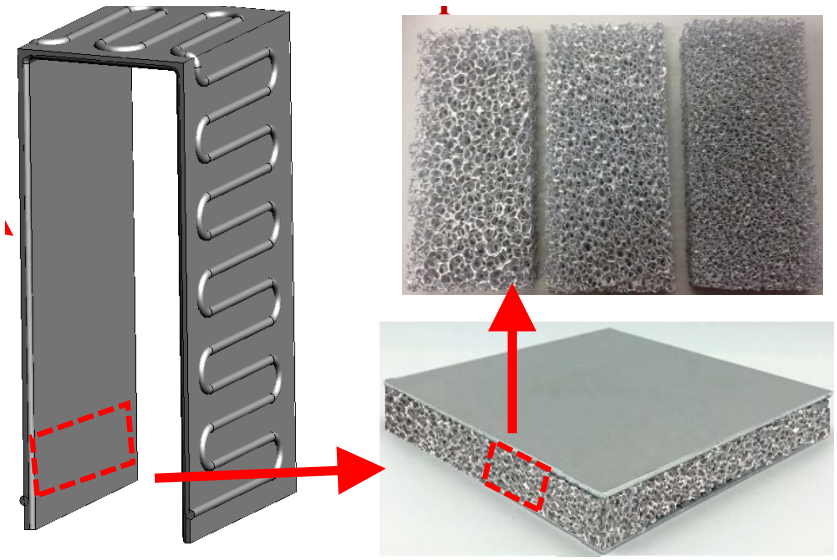
- Appliances integration & prototyping for high efficiency and grid responsiveness
- Cross-cutting capabilities across domains
- 120V low-cost appliances
- Grid support through peak load shift

Fast dryer

Thermoelectric dishwasher



Oven with recycled reinforced composites



Refrigerator with thermal energy storage

Low-cost refrigerant residential test appliance facility

Renovated high-bay space in Building 5800 for Residential Building Technologies Research:

- Ability to test residential appliances employing A2L Flammable Refrigerants
- Temperature test capability from -35^{0}C to +57^{0}C

Yarnell Station research house

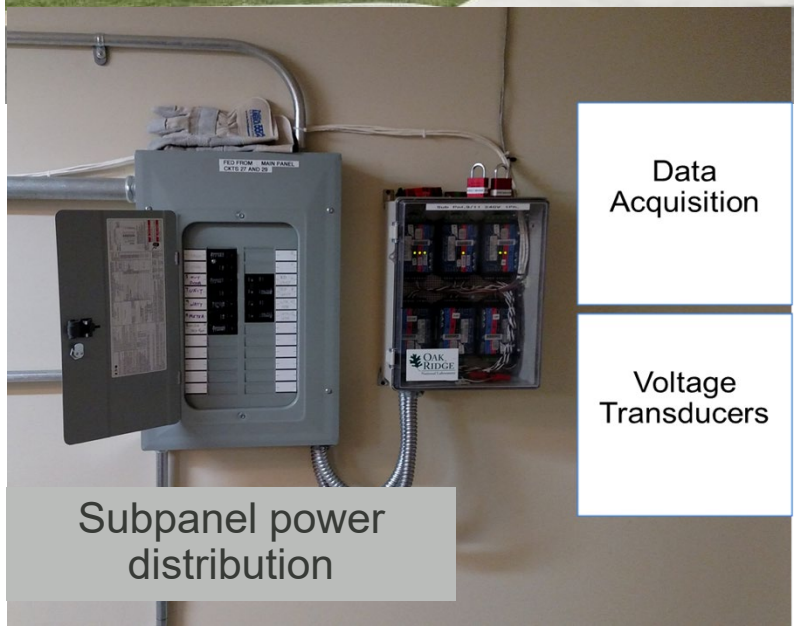
A single-family detached house

Occupancy simulated with heaters and humidifiers

Devices installed: HVAC, WH, electric vehicle (EV), photovoltaics, battery, pool pump, smart lighting, smart switch

Controllability: Local and cloud-based home energy management system (HEMS), OEM-specific

Measurement: Temperature, humidity, water consumption, electricity, outdoor weather (~100 instrumentation points)



Manufactured home retrofit program

BTRIC's manufactured test home evaluates updating strategies and costs/installation issues.

21 million people live in manufactured housing in the U.S.

Energy costs are often higher in these homes because of minimum energy efficient HVAC and water heating equipment.

Manufactured homes present a prime opportunity for reducing energy consumption and demand.

This testbed will be a model for duplicating success in additional development projects across the U.S.

Heat, air and moisture chamber

Capabilities

One sub-chamber represents indoor and the other mimics outdoor conditions

Simulates indoor temperatures between 60°F to 90°F and outdoor temperatures between 0°F to +150°F

Subjects wall specimens to 10 to 100% relative humidity and rain, solar radiation, and pressures from wind and wind gusts that range from -30 to 30 pounds

Sensors measure airtightness of the wall specimen during pressurization and depressurization testing, temperature, relative humidity and water content of any material inside the specimen

Unique Characteristics

Air tightness
Water penetration level
Aging and resilience testing
Variance in air infiltration
Reads any climate file, recreates weather

Partners – Industry/Other

Assess quality of surfaces in real-time

Flat and Level Analysis Tool (FLAT)

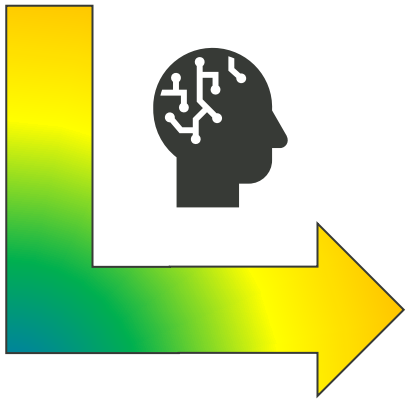
Provides real-time feedback on flatness, levelness, or drainage paths for a variety of surfaces

Slabs: foundations, floors, roofs

- Buildings, parking garages
- Concrete
- Cross-laminated timber

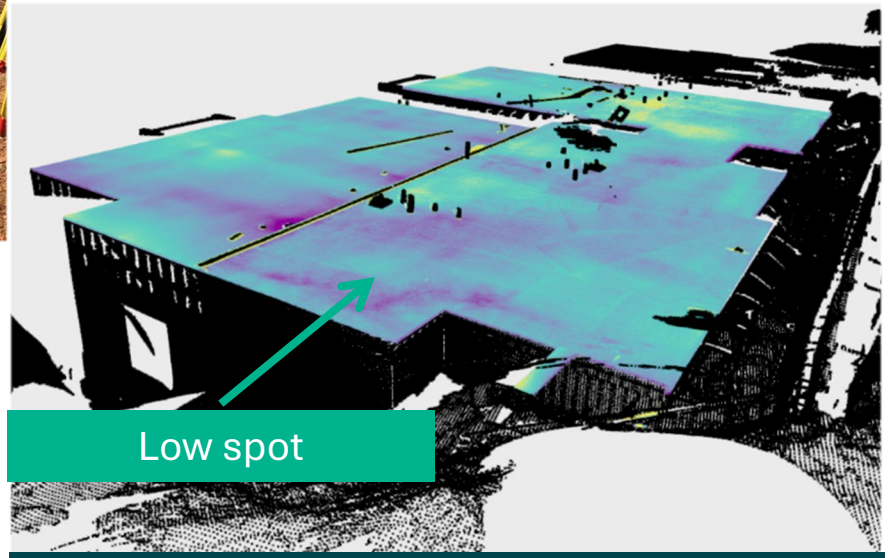
Runways and roads

New construction and retrofits



Less than 1 minute

Feedback in real-time while installers are at the jobsite



Analyzes laser scans to provide real-time feedback in less than 60 seconds

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Real-Time Evaluator tool

Born qualified assembly of structural building components: ORNL's Real-Time Evaluator expedites safe nuclear construction

The RTE enables a ***Born Qualified*** assembly process and eliminates final placement inspections at the end of the project.

Problem: Large concrete panels must be placed with extreme accuracy to ensure operational safety in nuclear facilities. Current installation procedure is slow, costly, prone to errors, and relies on inspection after construction.

Time and Cost: One hour to install one panel at a crane cost of $4,000 per day.

Challenge: Misalignment compromises safety.

Solution: ORNL's Real-Time Evaluator (RTE) provided fast and accurate feedback during placement of a 24ft-tall, 30-ton wall panel. RTE detected incorrect panel placement in 15 minutes and delivers feedback in under 3 minutes, nearly 20× faster than the current method.

Recent Innovations

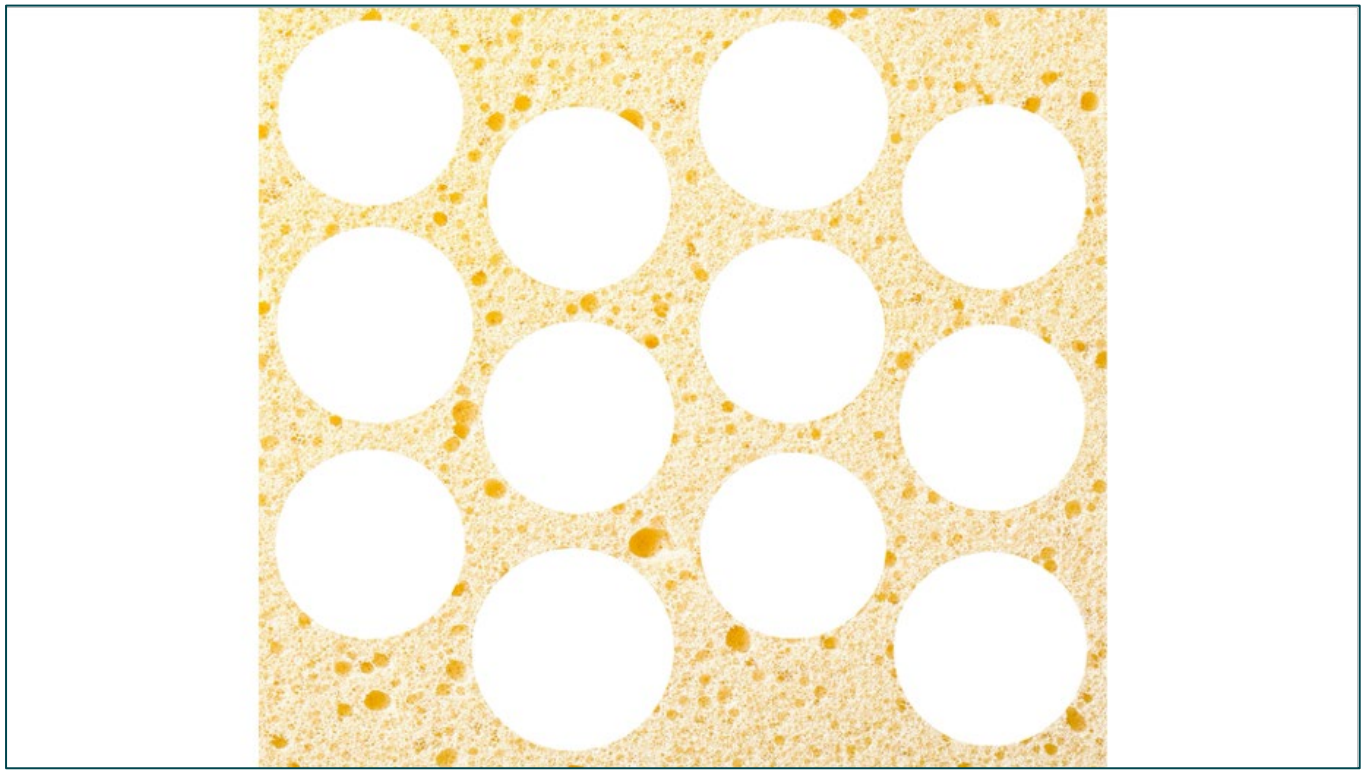
Forever R advanced polymeric facer technology

With foam insulation, ambient gases diffuse into foam cells, while blowing agents diffuse out.

ORNL's Forever R Facer film provides a barrier to gas diffusion in foam insulation.

Forever R enables an aged R-value of 7.5, compared to the commercial benchmark of 5.8, which is more than 30% improvement.

The metalized film strongly adheres to the polymer layers.



Enables long-term energy savings and translates to more than 2.3 billion in annual savings to American homeowners.

Thermoelectric dishwasher with enhanced drying

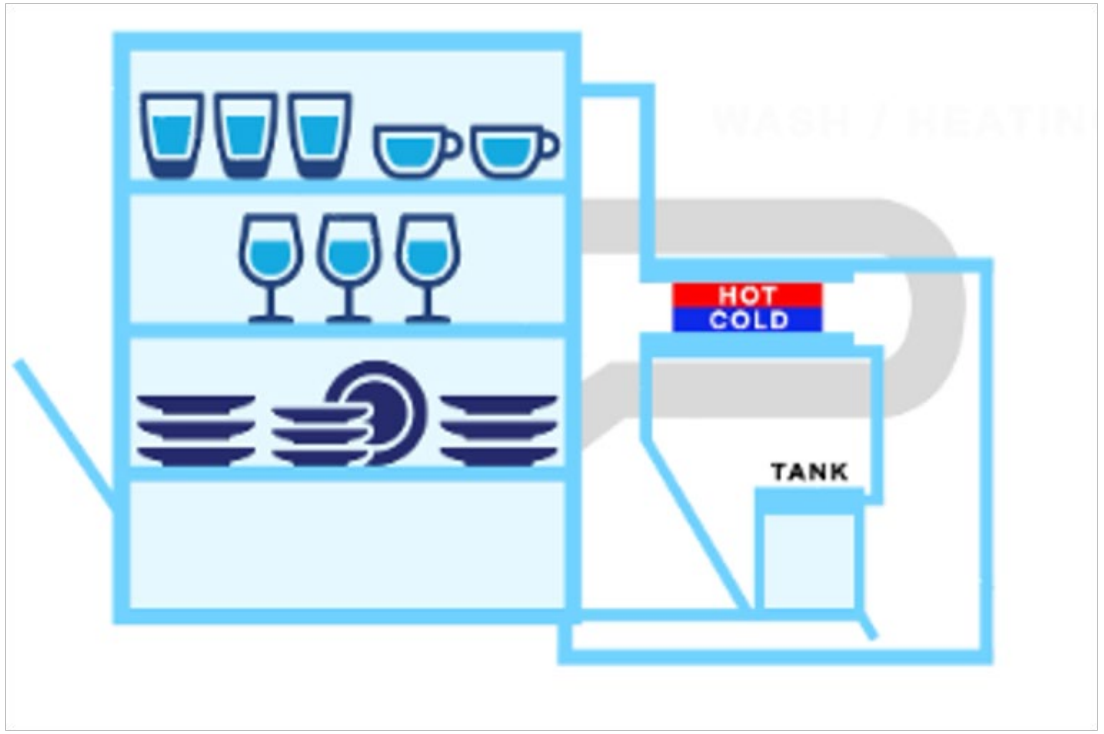
Uses a solid-state heat pump integrated with wastewater heat recovery.

Most dishwashers are “open loop” thermal systems that discard heated water during the drain cycle.

ORNL’s thermoelectric dishwasher is a closed-loop thermal system with captured wastewater acting as a thermal battery.

The captured energy delivers more heating capacity to wash water than the electric power it consumes.

16.4% less energy used for drying cycle and 31.5% reduction in total machine.



Compact, vibration-free, virtually silent, with gentle dehumidification and eliminates release of steam in the kitchen.

Combined washer/dryer with thermal energy storage

ORNL developed a ventless heat pump washer and dryer combined with thermal energy storage (TES).

Built-in heat pump washer/dryer sits on top of a pedestal housing a TES unit with an external evaporator.

Reduces drying time by more than 20%.

TES unit is charged during the washing cycle and discharged during the drying cycle.

The pump recovers waste heat from moist exhaust air, removes water vapor and provides heat for drying.

Cleans laundry at lower cost in one space-saving, efficient appliance.

DuoDefend flame retardant

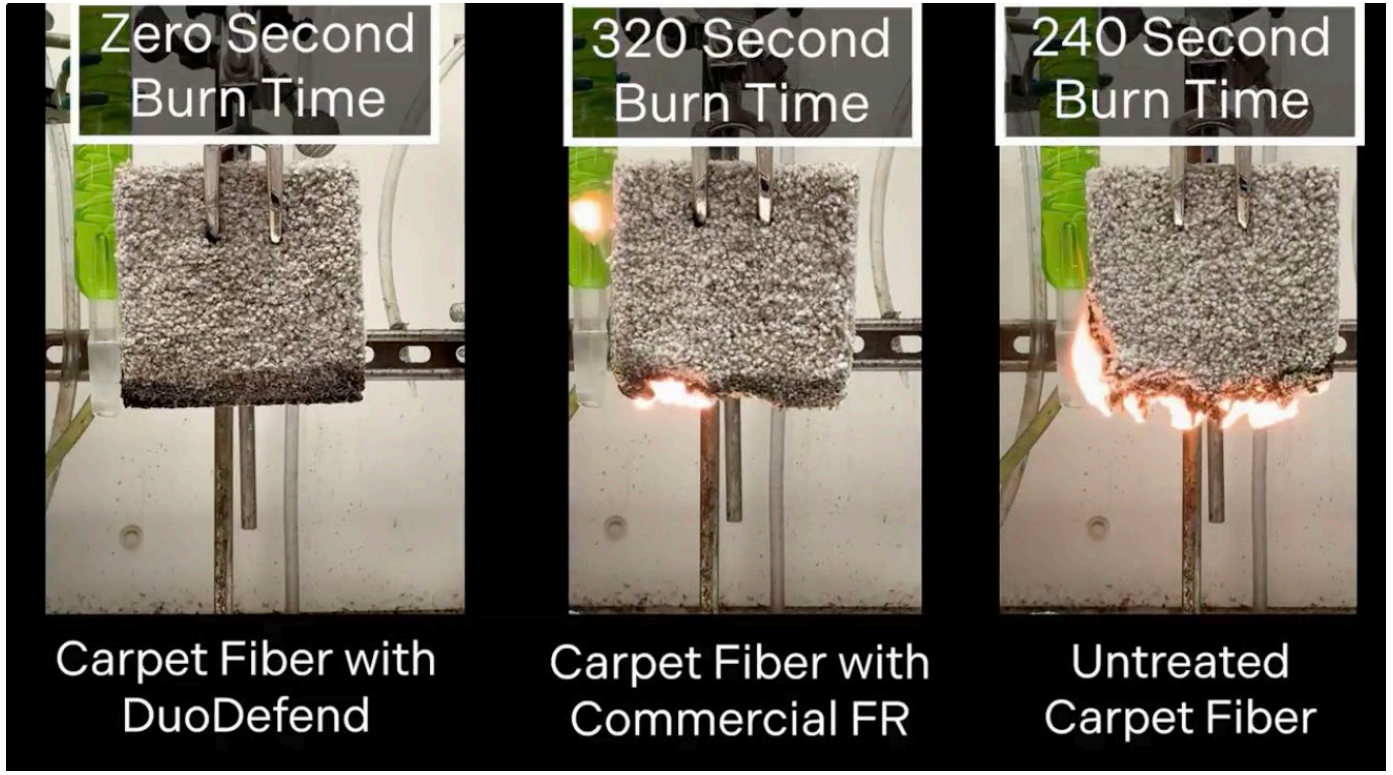
ORNL-developed family of affordable phosphate-based flame retardants that has dual flame retardancy mechanisms – gas and condensed phase.

Made from waste feedstocks from forest and plastics industries.

Non-toxic and easy to produce.

Can be incorporated into materials through processes like spraying.

Can be applied to many substrates, from building materials to paper and polymers.



Zero second burn time on carpet as compared to commercially available flame retardants.

New Projects

Liberty Place – new construction apartment building

In collaboration with the Knoxville Community Development Corporation, ORNL is conducting collaborative research at Liberty Place, a new apartment building for veterans, using sensors and data loggers to measure and validate the building energy performance.

Goals:

- Designed for energy efficiency
- High performance equipment
- Enhanced long-term performance
- Results will be shared with other communities

Source: kcdc.org

Home Energy Management System (HEMS) for control deployment in multi-family housing in Murfreesboro, Tennessee

- Investigating how multi-family housing occupants can benefit from energy efficiency and incentives for participating in DR programs while simultaneously reducing the stress on local electric grids.
- Deployed optimization and ran data analysis on occupied houses for both cooling and heating seasons.
- **The average opt-out was around 23% and the average peak reduction was around 60% .**

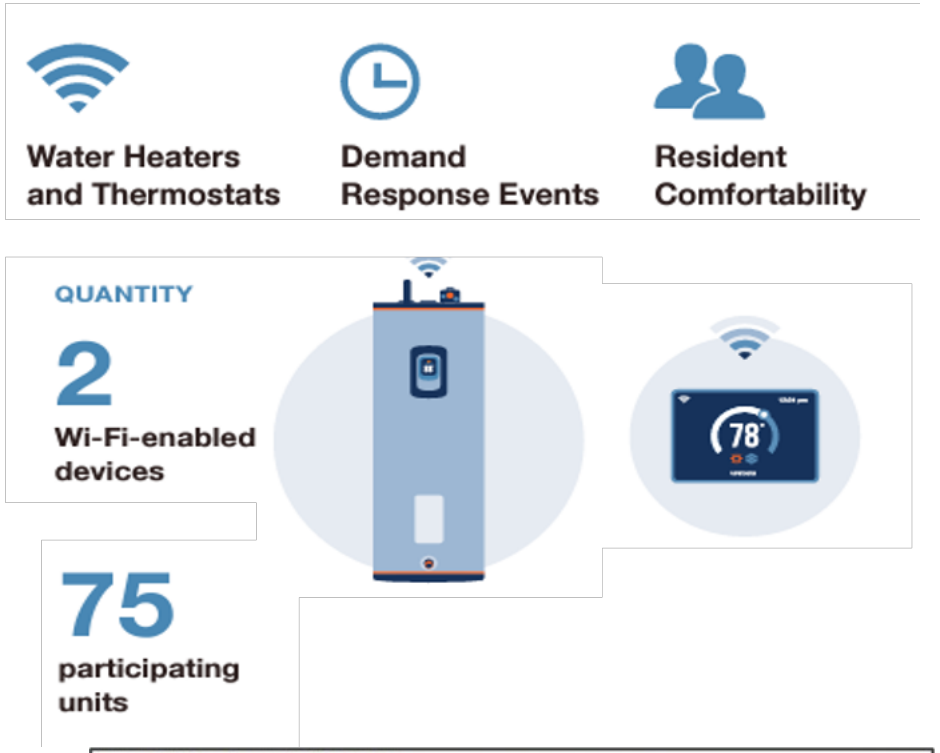


Table 9. Average monthly energy saving and power reduction in 2025

Month	Total participant num	Average opted-out count	Energy saving - Including/Excluding opted-out (%)	Peak power reduction – Including/Excluding opted-out (%)
Jan 25	12.0	3.0	37/39	52/53
Feb 25	12.5	4.5	27/30	37/38
Mar 25	13.0	2.0	15/35	53/76
Apr 25	11.5	1.5	38/53	60/67
May 25	12	3.5	61/59	76/71
Jun 25	10.7	3.7	12/13	26/30
Jul 25	12.0	3.7	41/46	49/52
Aug 25	9.7	3.3	33/51	48/70

Source: Connecting MHA

Energy efficiency retrofit strategy for City of Knoxville buildings

In collaboration with the City of Knoxville, ORNL is analyzing energy and operational data from city-owned commercial buildings and conducting site visits to understand building conditions and issues.

Goals:

- Reduce peak power demand and improve grid resiliency.
- Improve energy efficiency while maintaining occupant comfort.
- Improve affordability by reducing building energy costs.
- Develop retrofit guidelines for city-owned commercial buildings.

The Knoxville Convention Center will be the first study to identify the major issues with energy efficiency and address those that have the fastest return on investment.

*Photo of the City County Building is from https://www.downtownknoxville.org/

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