U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Ultra-Clear Aerogels for Insulated Glass in Refrigeration Doors (CRADA AeroShield Materials)

Oak Ridge National Lab
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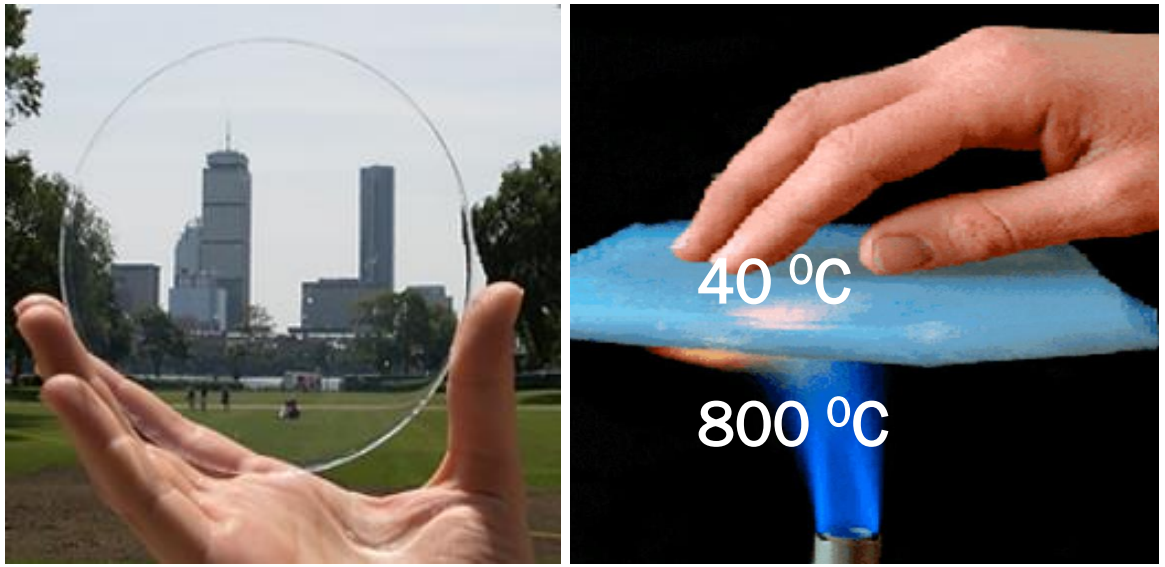

Project Summary

Objective and outcome

The project is focused on the development and performance evaluation of ultra-clear insulation for display case doors for refrigeration systems. A major portion of cooling load is associated to the heat transfer from the transparent doors. The proposed solution will enable at least 15% reduction in overall energy consumption due to improved thermal insulation.

Team and Partners

Oak Ridge National Lab

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AeroShield Materials

Kyle Wilke, Elise Strobach

OAK RIDGE National Laboratory

AeroShield

Stats

Performance Period: Oct 2021- Mar 2023

DOE budget: $80k/year, Cost Share: $20k

Milestone 1: Materials characterization

Milestone 2: Durability assessment

Milestone 3: Prototype development and performance evaluation under realistic operating conditions.

Problem

- Wide-spread deployment of advanced materials with novel characteristics in applications such as refrigeration is key to achieve net-zero GHG energy economy.
- Commercial refrigeration systems contribute to 57% of total electricity consumption of supermarket.
- Doored display cases present an efficient approach, yet heat transfer from transparent door causes extensive load.

Electrical Energy Consumption	Doored Display Case (Store #1)	Open Display Case (Store #2)
Compressors (kWh/day)	11.70	42.20
Lights (kWh/day)	11.93	5.18
Fans (kWh/day)	4.58	5.69
Anti-Sweat Heaters (kWh/day)	15.50	--
Total (kWh/day)	43.72	53.07
Total (kWh/day per ft)	1.71	2.21

Source: Fricke, Brian and Becker, Bryan, "Energy Use of Doored and Open Vertical Refrigerated Display Cases" (2010). International Refrigeration and Air Conditioning Conference. Paper 1154

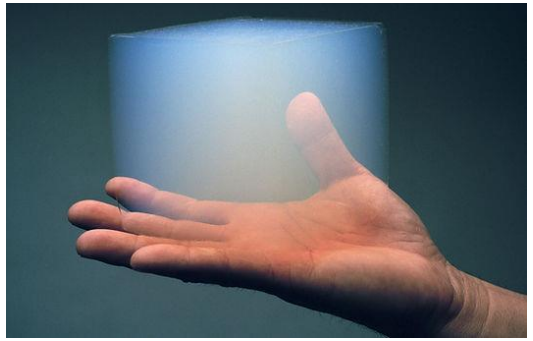
Door display case

Open display case

Source: https://www.hillphoenix.com/display-cases/display-cases/

Problem

- Silica aerogels are the porous nanostructured form of silicon dioxide, which are the most common type of aerogel.
- With the advantage of low-thermal conductivity and visible transparency, they have been examined by various researchers to develop highly energy-efficient windows, however, there have been rare efforts for their application in commercial refrigeration systems.
- The extreme operating conditions, sever thermal gradients as well as cyclic mechanical stresses can impact the performance of the highly brittle materials.
- The deployment strategy requires in depth understanding of commercial refrigeration operations as well as the thermal and mechanical properties of aerogels.



Source: https://www.aeroshield.tech/technology

Approach

Phase I

- Establishment of value proposition
- Baseline testing of existing product and performance analysis
- Development of prototype (aerogel sandwich approach)
- Performance evaluation (at two scales) and data analysis

Phase II

- Manufacturing process scale-up (20X larger surface area)
- Development of scaled-up prototype and deployment
- Field study using a standard display case door
- Commercialization strategy and techno-economic analysis

Alignment and Impact

- The Department of Energy's (DOE) Building Technologies Office (DOE BTO) has a goal to reduce the energy use intensity (EUI) and carbon emissions of energy service equipment by 50% compared to today's best common practice by 2050.
- As such the project is highly aligned with the DOE's strategic goal. Furthermore, the efforts will also lead to the development of advanced windows for building applications.
- Contractor has developed an extended program where the latest developments in advance materials for windows have been evaluated. Furthermore, there is extensive framework for the commercial refrigeration application particularly for the display cases under controlled environment

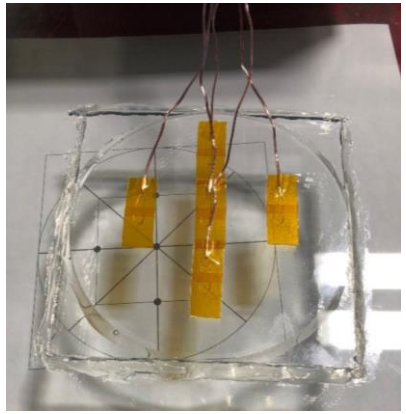
Risk Mitigation

- Durability of material and robust design
  - The durability studies under cold environment conditions
  - Engagement of OEM of refrigerator display case to ensure the final design is durable and robust
  - Feedback from end users during the field evaluation for fine-tuning and design optimization
- Cost effectiveness
  - Optimize the manufacturing process of aerogel to reduce the overall cost
  - Technoeconomic analysis will be performed by AeroShield Materials and third-party firm
  - Aerogel cost at less than $2/sqft for a 3 mm thick sheet based on lab-scale manufacturing
- Market acceptance
  - Engagement of an OEM to promote the technology to ensure that the technology can be released to the market

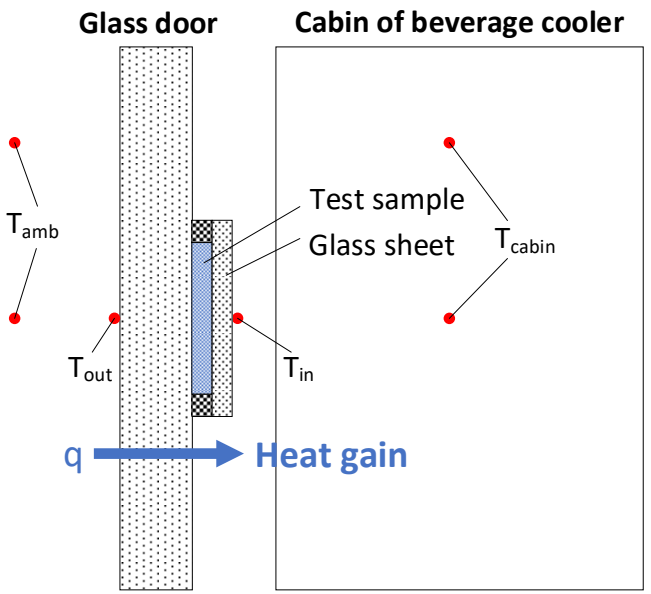
Progress

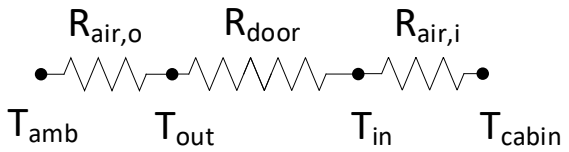
Heat transfer evaluation of circular samples

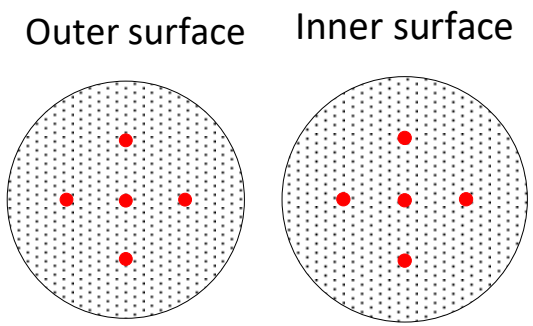
Circular samples on the inner surface of glass door



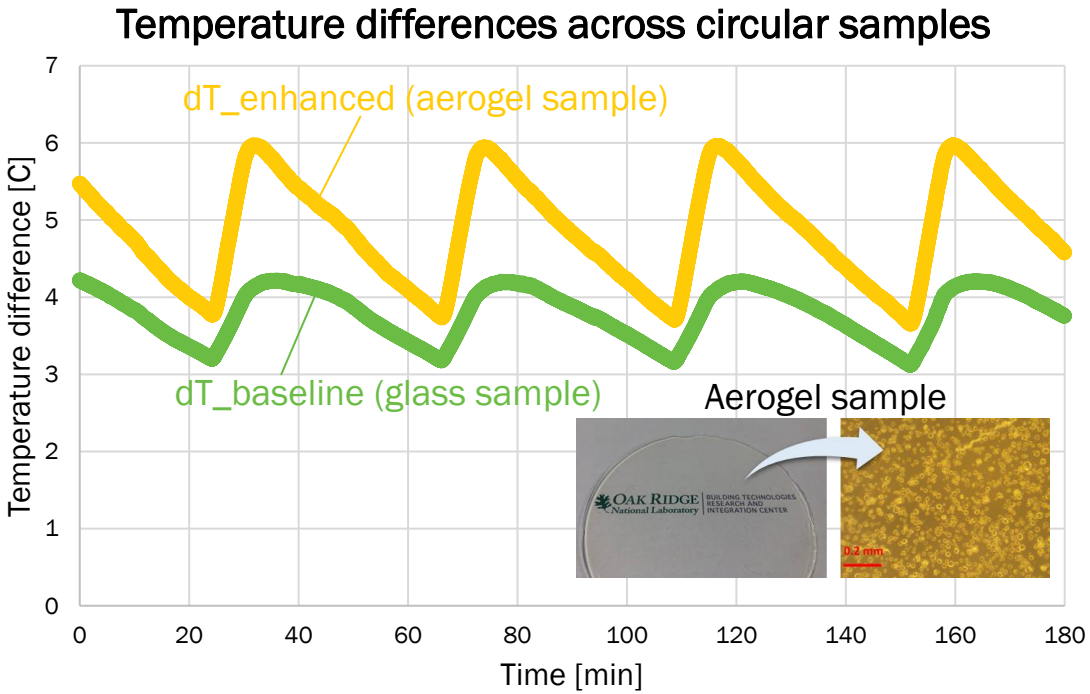
Surface temperature measurement







Schematic of sensor locations



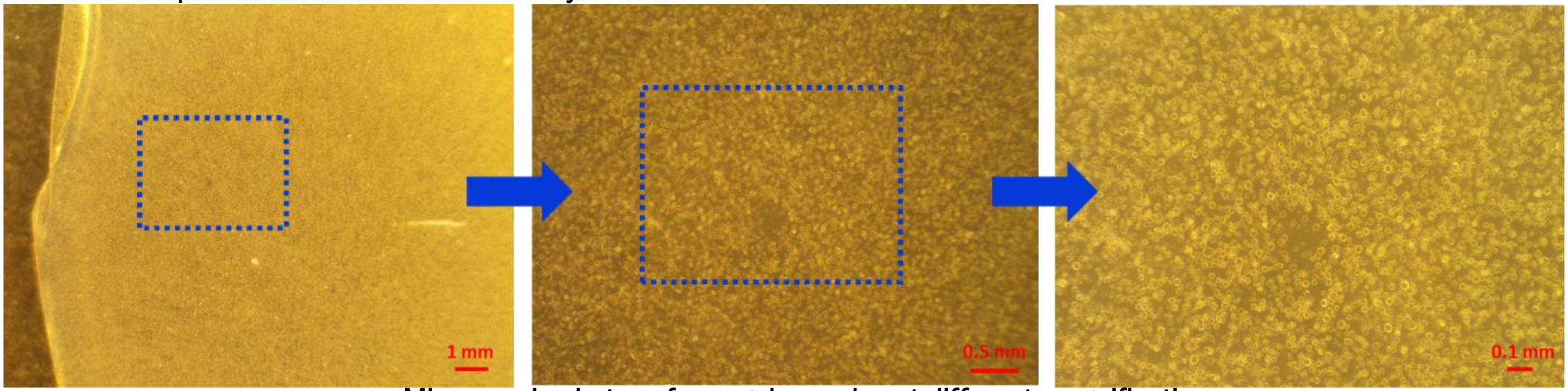
- An 18-hour experiment was conducted to compare the heat transfer across the two samples.
- The preliminary results indicated that the temperature difference across the enhanced sample (silica aerogel) was around 27.9% higher than the baseline case (glass sheet).

Progress

Cold-environment durability tests of circular samples

Test setup for cold-environment durability tests

- The cabin temperature was controlled between -6 to -10°F
- Microscopic photos were taken at different locations prior to the durability test.
- The samples were take out from the fridge for tracking the change after 24 hours, 2 weeks, and 1 month.



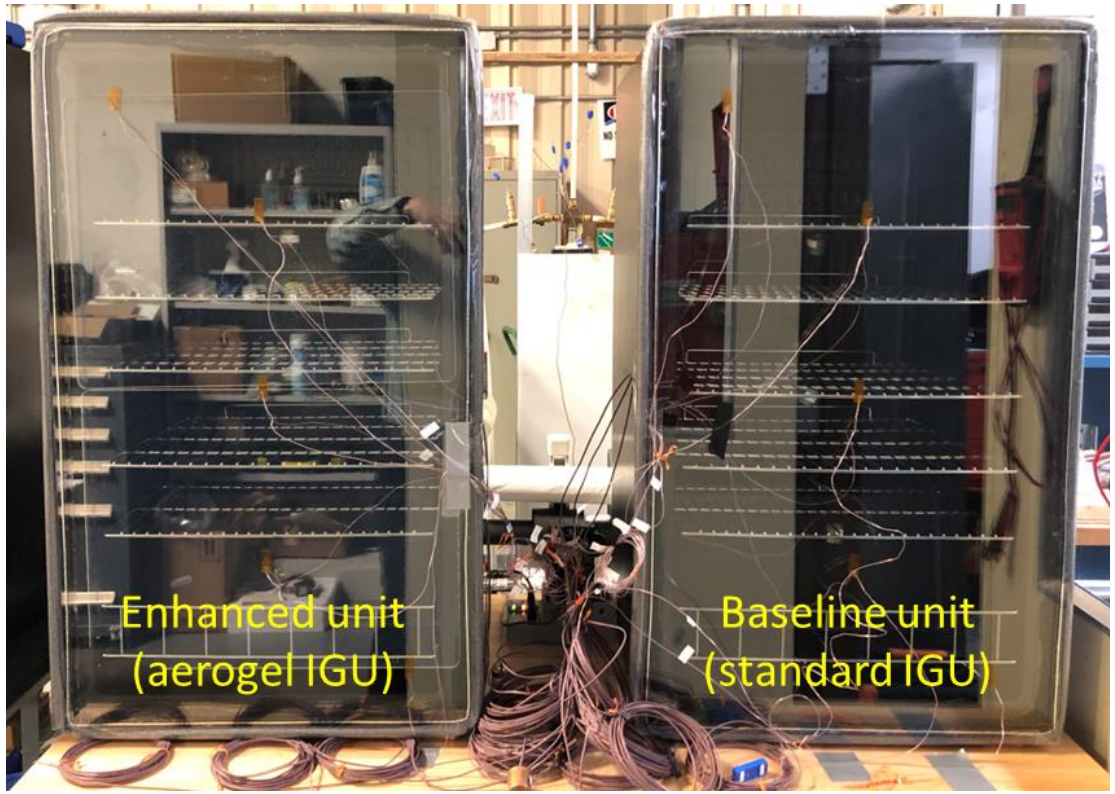
Microscopic photos of aerogel samples at different magnifications

No significant change or degradation of the aerogel sample in the cold environment was observed after 1 month.

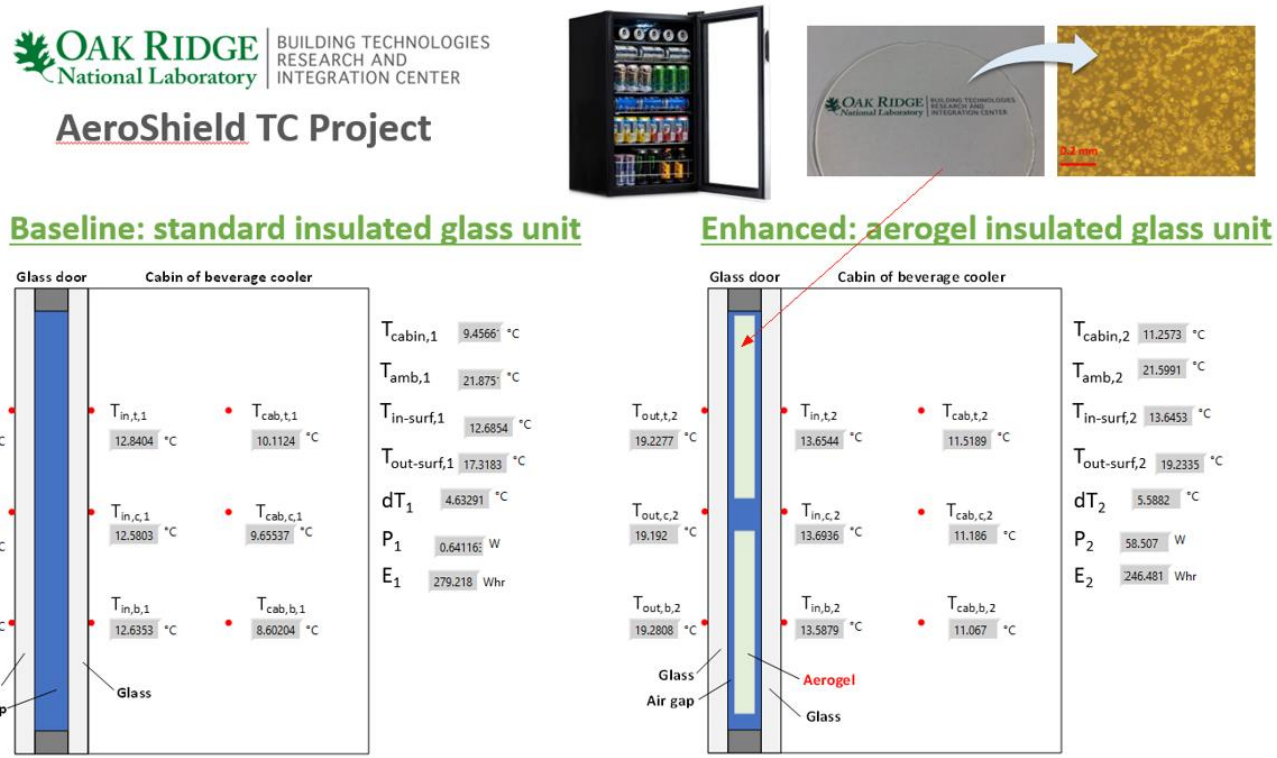
Progress

Depolyment of aerogel in the glass door of beverage cooler

- Two customized insulated glass units were made for the beverage cooler: standard IGU and aerogel IGU.
- In the enhanced unit, two aerogel sheets (17” x 13”) were embedded in the double-pane glass.
- Thirty-two T-type thermocouples and two watt transducers were used to monitor the performance.



Beverage coolers with aerogel IGU and standard IGU



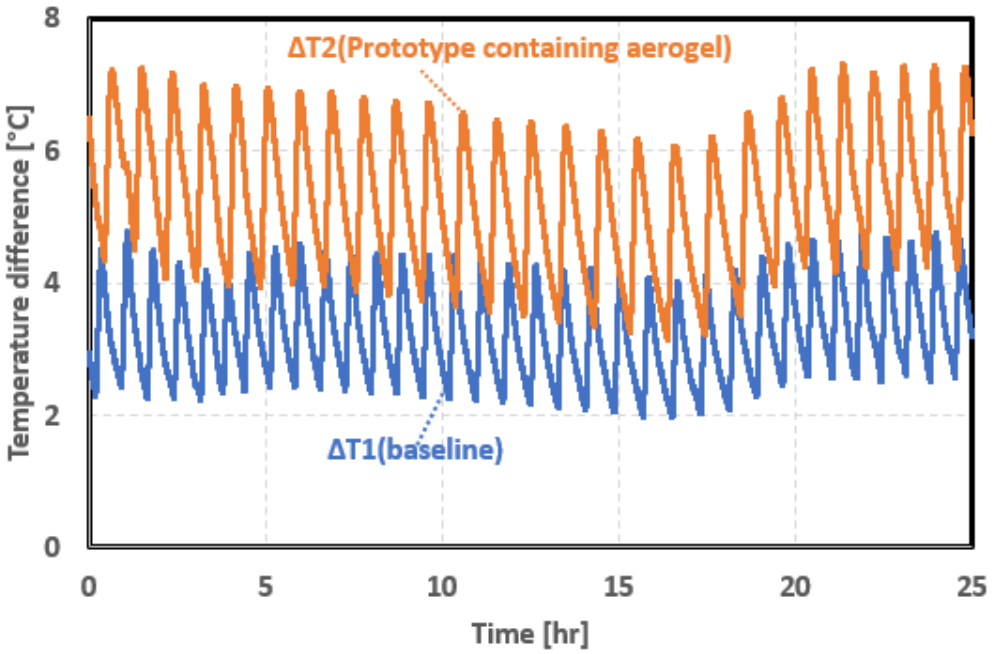
LabView program for data collection

Progress

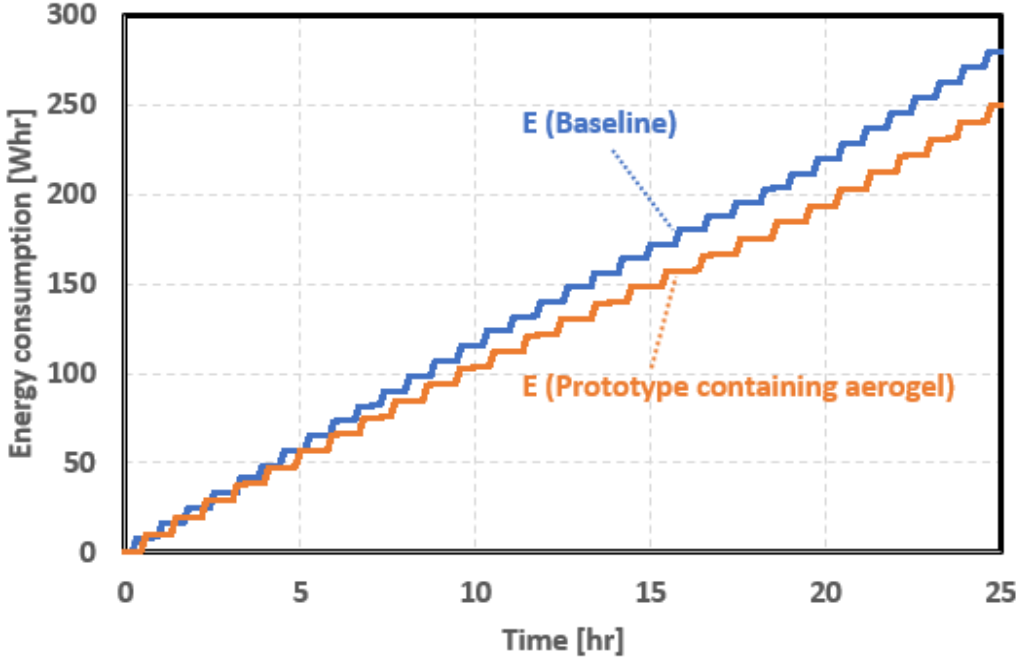
Depolyment of aerogel in the glass door of beverage cooler

- A 25-hour experiment was conducted to compare the performance of the two beverage coolers.
- The average temperature differences across the enhanced IGU and baseline IGU are 5.29 °C and 3.23 °C.
- Compared to the standard IGU, the beverage cooler with the enhanced unit consumed 10.5% less electricity during a full day's operation.

Temperature differences across the IGUs



Overall energy consumptions of the beverage coolers



Silica aerogel effectively improves the glass door insulation and reduces the energy consumption of the tested cooler.

Thank you

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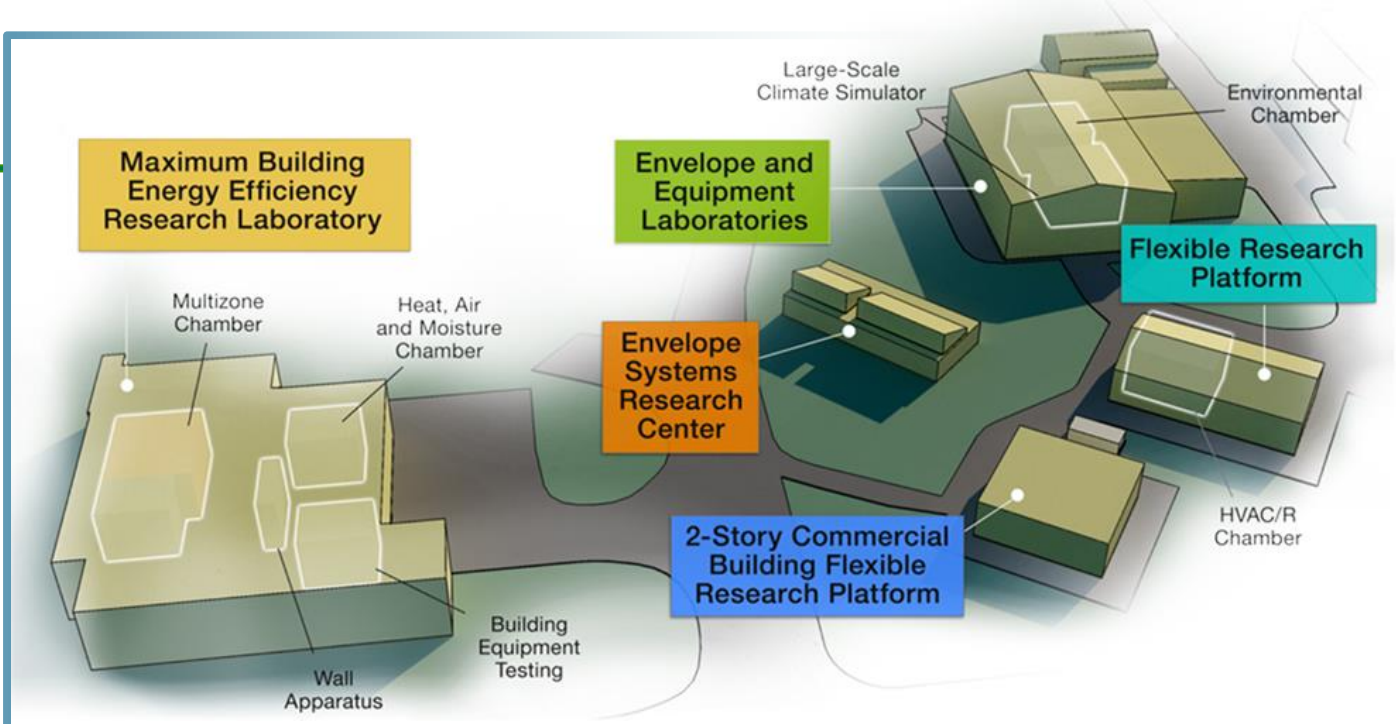

ORNL's Building Technologies Research and Integration Center (BTRIC) has supported DOE BTO since 1993. BTRIC is comprised of 60,000+ ft^2 of lab facilities conducting RD&D to support the DOE mission to equitably transition America to a carbon pollution-free electricity sector by 2035 and carbon free economy by 2050.

Scientific and Economic Results

236 publications in FY22
125 industry partners
54 university partners
13 R&D 100 awards
52 active CRADAs

BTRIC is a DOE-Designated National User Facility

REFERENCE SLIDES

Project Execution

	FY22				FY23	
	Q1	Q2	Q3	Q4	Q1	Q2
Past Work						
Q1 Milestone: Fabrication of clear aerogel samples	◆					
Q2 Milestone: Durability evaluation of aerogel samples		◆				
Q3 Milestone: Development of prototype (aerogel sandwich approach)			◆			
Q4 Milestone: Performance evaluation (at two scales) and data analysis				★		
Q2 Milestone: Final report						◆