

Building Envelope Campaign



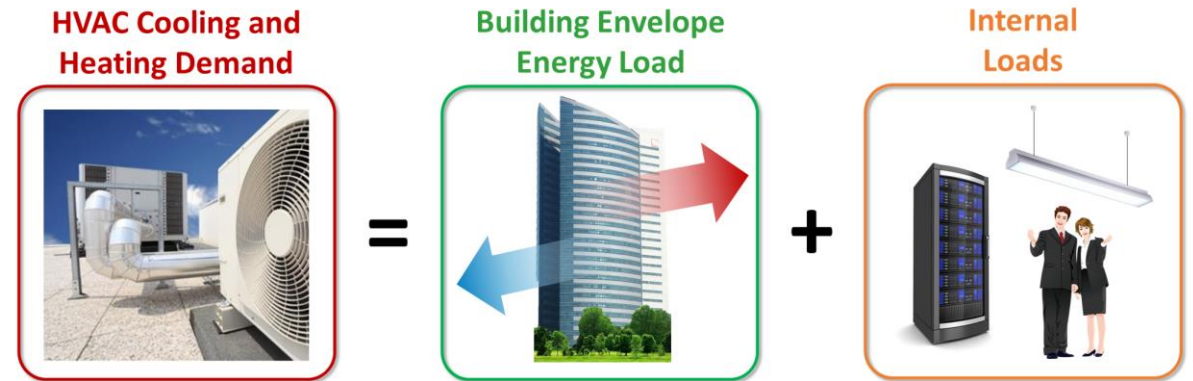
Oak Ridge National Laboratory
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Project Summary

Summary

The Building Envelope Campaign (BEC) is a program designed to help building owners and managers create more energy efficient buildings. This will be done by setting goals for building envelope performance, determining available energy savings, and providing technical support & resources to building owners and managers.

Our overarching goal was that our participants implement the latest and greatest envelope technologies and do not have to spend much time on creating a model or doing measurements.



Team and Partners/Organizers



Stats

Performance Period: Oct 2020 – Sept 2023

DOE budget: \$850 K, Cost Share: \$0

Milestone 1: Completed tool development

Milestone 2: Integrated into web-based platform

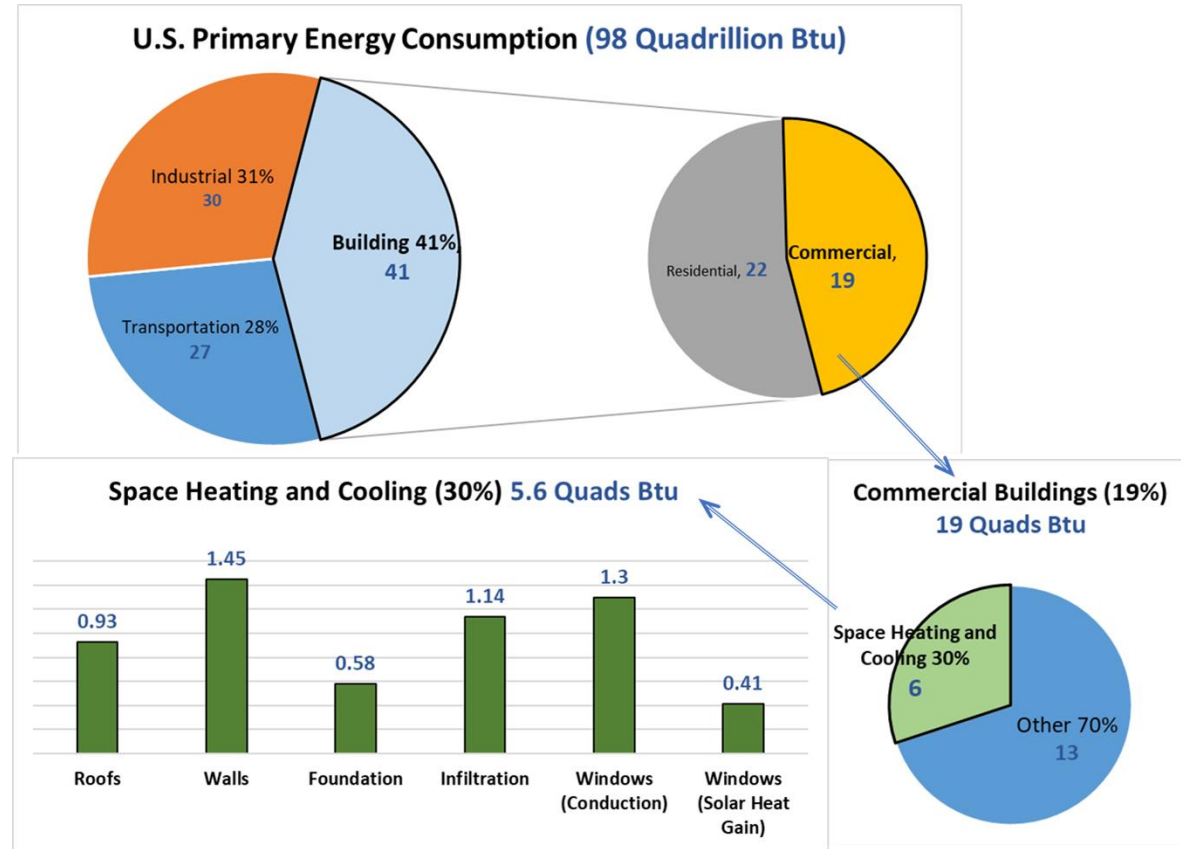
Milestone 3: Campaign deployment and execution

Problem

The envelope (windows, walls, roofs) accounts for approximately 30% of the primary energy consumed in commercial buildings. Lacks energy efficient envelope market transformation:

New construction: Owners do not see benefit going beyond the code requirements due to incremental savings and high cost

Retrofit: Payback period, based on energy savings alone, is long



2010 U.S. primary energy consumption (Quads)
1 Quad = 10^{15} Btus (~293 billion kWh)

Figure Source: Windows and Building envelope Research and development: Roadmap for Emerging Technologies

Approach: Set Building Envelope Campaign Goals

Motivate action and increase awareness

- Communicate and demonstrate the value of investing in high performance building envelope technologies for both new and existing commercial buildings

Recognize leaders

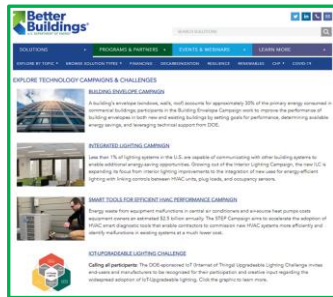
- Show how industry leaders are using the BEC to achieve high performing building envelope systems

Demonstrate and document

- Quantify energy and cost savings of integrated design, construction, commissioning, and maintenance of high performing envelope systems

Approach: Outreach

Website



- Better Building
- Envelope campaign

Webinars



- Better Building Summit and Webinars
- Architecture and Construction: Continuing Education Center

Conferences



- 15th International Conference on Durability of Building Materials and Components - Barcelona, , Spain
- 2022 ACEEE Summer Study on Energy Efficiency in Buildings

Publications



- Journal of Civil Engineering and Architecture
- Journal of Building Engineering
- ACEEE Conference Proceedings

Newsletters



- Newsletters
- Organizers

Testimonials



- Project testimonials available on YouTube
- Project snapshots and videos available on website

Approach: Develop a Simplified tool

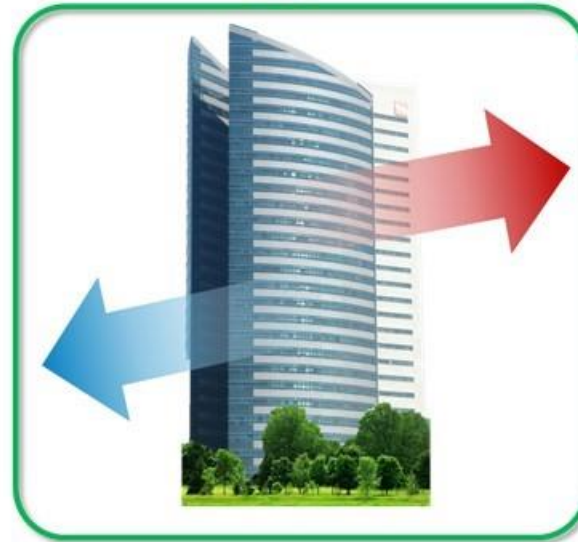
The Building Envelope Performance (*BEP*) Metric

HVAC Cooling and Heating Demand



=

Building Envelope Energy Load



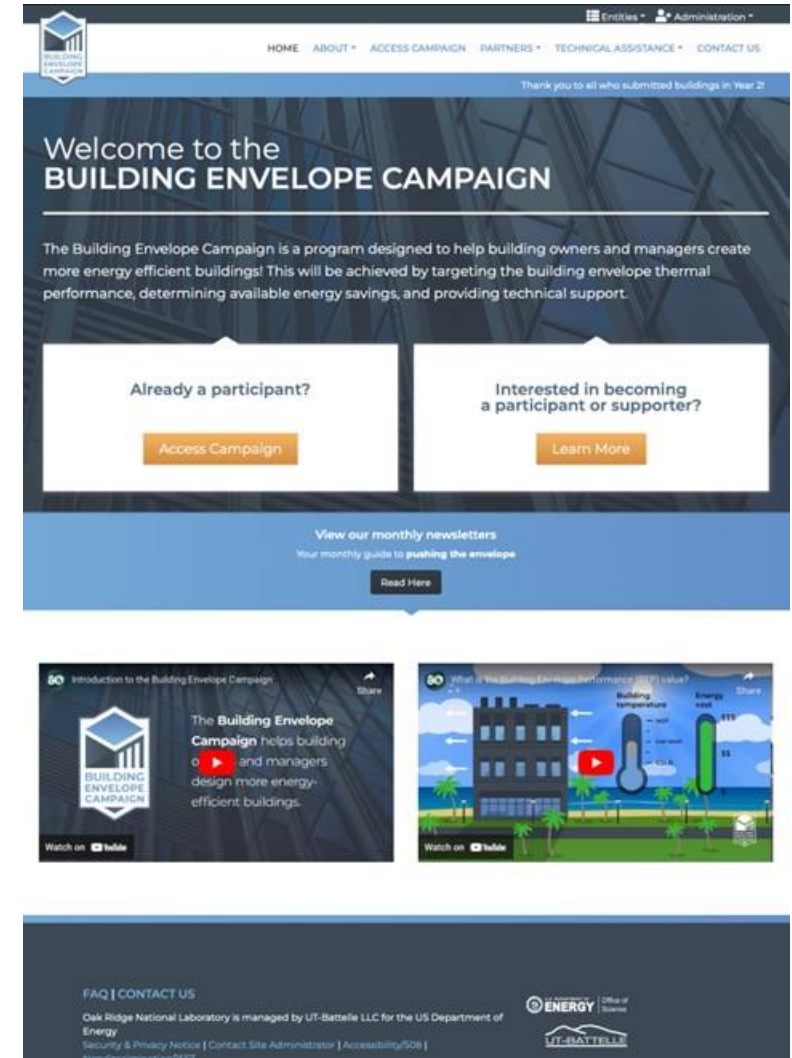
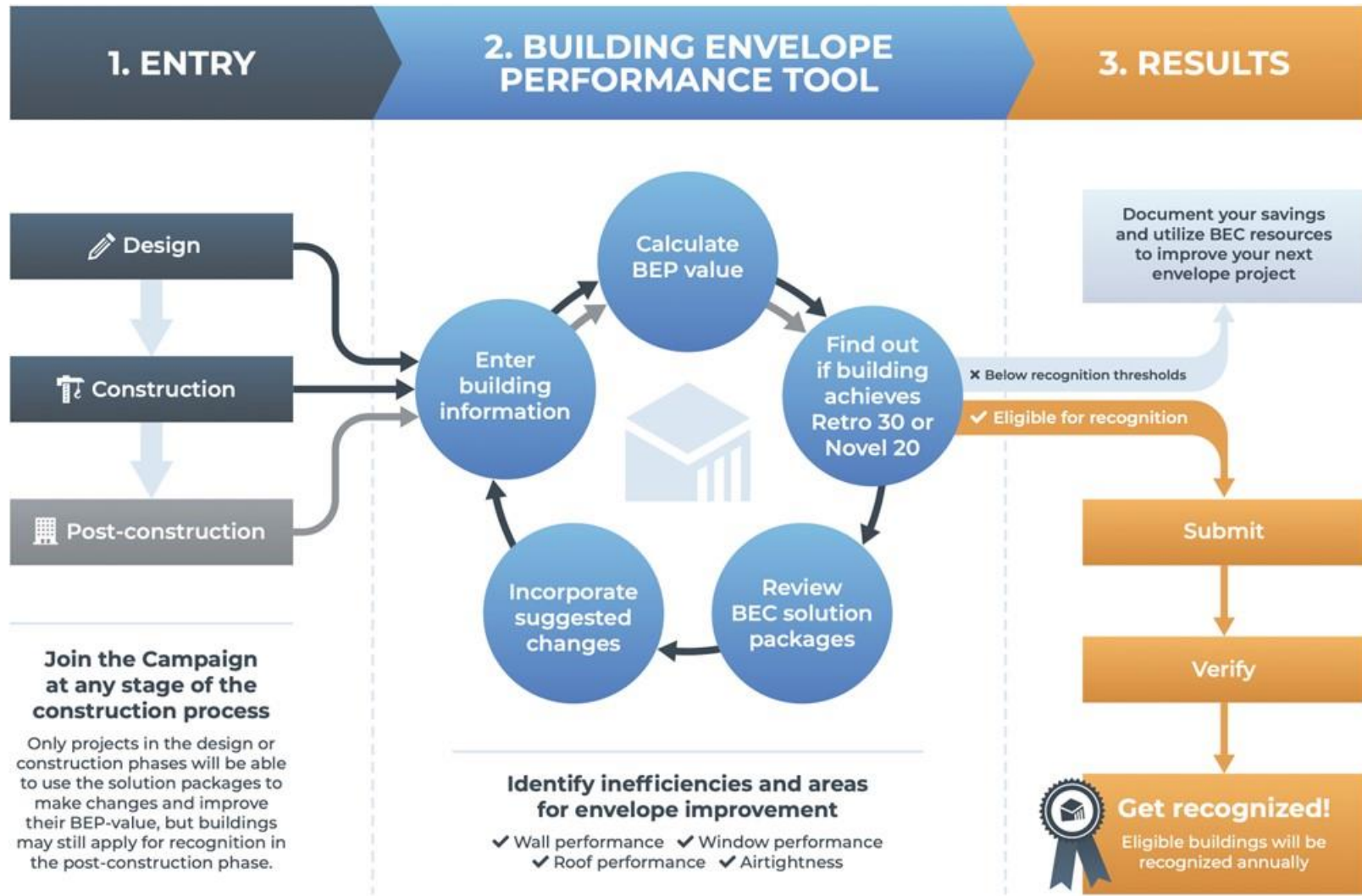
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Internal Loads



$$\text{Building Envelope Energy Load (kBtu)} = \text{BEP (kBtu/ft}^2\text{)} \times \text{Envelope area (ft}^2\text{)}$$

Approach: What is the plan to deliver intended outcomes?



Enter building information

User enters the building type, climate and geometry. 16 DOE reference building types as a starting point.

Building Type

Is this a new construction or retrofit? New Construction Retrofit

Approximate year of building construction?

Climate

Select the climate zone where building is located?

Select the state where building is located?

On average, Tennessee has a 7 year delay in adopting new construction code.

Select the built environment

Geometry

Select the type of building. Default values represent reference building geometries, so please change as needed to best match your building.

Conditioned Floor Area

Building Height

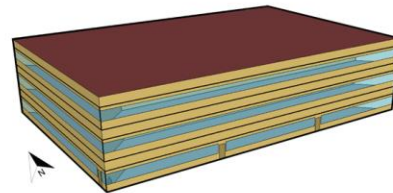
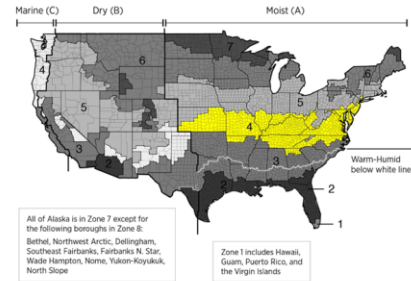
Building Floors

Total Surface Area of the Walls (including windows)

North	South	East	West
<input type="text" value="4280"/> ft ²	<input type="text" value="4280"/> ft ²	<input type="text" value="2863"/> ft ²	<input type="text" value="2863"/> ft ²

Window Area

North	South	East	West
<input type="text" value="2108"/> ft ²	<input type="text" value="2108"/> ft ²	<input type="text" value="1405"/> ft ²	<input type="text" value="1405"/> ft ²



User then enters the properties of the building envelope, including the roof and fenestrations. Lastly, the user specifies the tightness of the enclosure.

Building Components/Material Properties

Default values for "Existing Building" are based on estimate code at time of construction. Please change as found necessary.

Existing Building

Wall R-value [Click here to access R-value calculator](#)

Predominant Wall Façade Material

Roof R-value [Click here to access R-value calculator](#)

Roof Surface Material

Window U-factor [Click here to access R-value calculator](#)

Window SHGC

Yes No Have you conducted blower door test?

Building Airtightness Value

Yes No Have you taken any additional steps to improve the airtightness of your building?

Planned retrofit

Wall R-value [Click here to access R-value calculator](#)

Predominant Wall Façade Material

Yes No This project uses EIFS system?

Roof R-value [Click here to access R-value calculator](#)

Roof Surface Material

Window U-factor

Window SHGC

Building Airtightness Value

Calculate the BEP

My Building



Building Envelope Performance (BEP)
 Congratulations you meet the requirements to receive the Retro 30 award

33% Improvement

Percent improvement compared to code or existing building if it's a retrofit

Existing Building Baseline

BEP (kBtu/ft ²)	27.7
Wall R-Value	10.4
Wall Façade Material	Stucco
Roof R-Value	16.1
Roof Surface Material	Blk membrane
Window U-Factor	0.60
Window SHGC	0.36
Air Leakage Rate scfm/ft ²	1.07

Retrofit Improvement

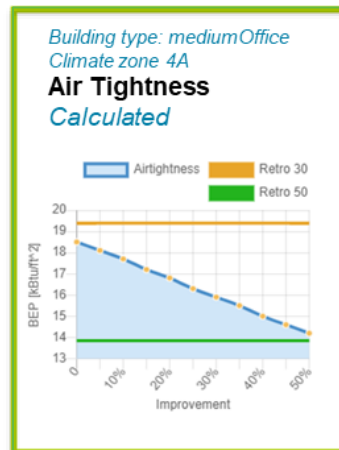
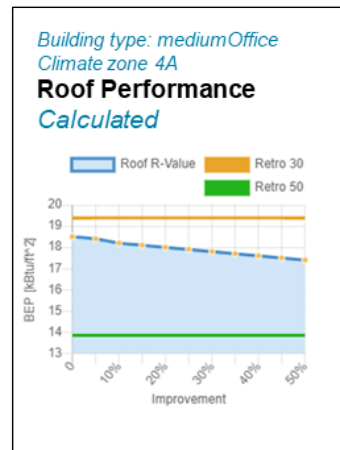
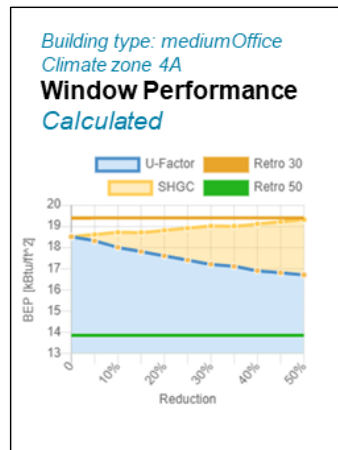
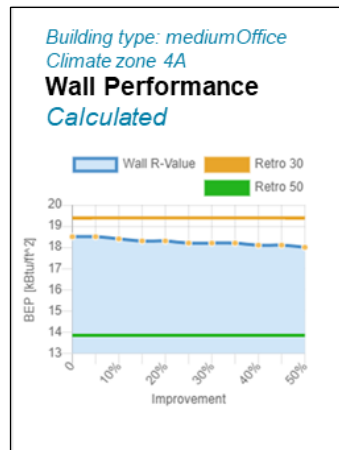
BEP (kBtu/ft ²)	18.5
Wall R-Value	30.0
Wall Façade Material	Stucco
Roof R-Value	16.1
Roof Surface Material	Blk membrane
Window U-Factor	0.25
Window SHGC	0.18
Air Leakage Rate scfm/ft ²	1.07
CO₂ Reduction lbs/year	39600

Building envelope performance (BEP) metric in kBtu/ft²

Carbon dioxide emissions reduction or avoidance in kgCO_{2eq}

Energy Performance Breakdown

Charts below indicate improvement potentials for various building characteristics. Improvements are displayed using the BEP-value together with award criteria.



Based on the inputs, points to the envelope property where the most significant improvement can be realized.

Recognition tiers and categories

Retro

- **Retro 30** – 30 to 49% improvement in performance of the building enclosure
- **Retro 50** – 50% or more improvement in performance of the building enclosure



Novel

- **Novel 20** – 20 to 39% improvement in performance of building enclosure compared to code
- **Novel 40** – 40% or more improvement in performance of building enclosure compared to code



Role Models

- **Technology role model** – deployment of novel/innovative building envelope technology or system
- **Equity in Energy role model** – improvements to structures that impact underserved communities



Honorable mention

- Recognized for making a positive impact to the building envelope campaign



Review solution packages and additional resources

Toggle: Retrofit New Construction

Filters: Window U-factor Window SHGC Wall Roof Airtightness

Commercially available technologies

Technology	Benefit	Tag
Exterior Liquid Sealant	Liquid applied flashing material that can be applied using an airless sprayer, brush or trowel. The benefit of using flashing materials is that it provides moisture protection between windows/doors and the enclosure significantly reduces air leakage resulting in reduced energy consumption.	Airtightness
Aerosol-Based Sealing Process	Aerosol based air barrier technology designed to reduce leaks through small penetrations and defects in the building enclosure. The benefit of this approach is that it reduces labor associated with detection and application of air barrier materials.	Airtightness

Available resources for each of the envelope properties that determine the energy performance of the building, retrofit and new construction

For each property there are resources for commercial technologies.

The users also have access to examples of deployment through case studies.

There are additional resources available to help guide practitioners to implement solutions to improve envelope performance.

Additional resources

- [The Air Barrier Association of America Understanding Air Barriers Air Barrier Systems](#)
- [Whole Building Design Guide – Air Barrier Systems](#)
- [U.S. Commercial Building Requirements and Measurements](#)

In addition to the solution packages, case studies and additional information, participants and supporter have access to ORNL's technical team to provide hands on support.

Case Studies

Title	Summary	Tag
ABAA Evaluated Air Barrier Assemblies	Air barrier systems that were evaluated/tested by ABAA in accordance with ASTM E 2357 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies. ABAA has set a maximum air leakage rate for wall air barrier assemblies as being 0.04 CFM/ft ² at a pressure difference of 1.57 lb./ft ² [0.20 L/(s·m ²) at a pressure difference of 75 Pa].	Airtightness
Air Barriers in High Interior RH Specialty Buildings: Considerations for Control of Moisture-Laden Air in Museums, Labs, and Natatoriums	No air barrier installed in original construction resulted in significant air leakage through the enclosure resulting in the movement of moisture laden air from a hot/humid interior to a cold exterior resulting in efflorescence of masonry and formation of ice on the roof's edge. In an attempt to mitigate air movement from the interior to exterior, the mechanical system was used to try and establish a condition of negative pressure in the interior. The size of the mechanical system was inadequate to establish such a condition. As a result, the leaks were identified and sealed. The building was still relatively leaky, but the mechanical system was able to establish a condition of negative pressure mitigating the movement of air to the exterior.	Airtightness



Dr. Mahabir Bhandari

Dr. Mahabir Bhandari, CEM, BEMP, LEED AP B+C, serves the BEC as a Technical Team Member. He is an R&D staff member in the Building Envelope Materials Research Group at ORNL. He has more than 20 years of experience in the field of building energy performance. Dr. Bhandari holds a PhD degree at Center for Energy Studies of Indian Institute of Technology, Delhi, India. He is a LEEDTM Accredited Professional Building Design+Construction and National Fenestration Rating Council-certified simulator and has made significant contributions to building energy performance software product development. Prior to joining ORNL, Dr. Bhandari was Technical Director at DesignBuilder Software, USA. He is chair of ASHRAE Technical Committee 4.5, Fenestration, a member of the International Building Performance Simulation Association and the Association of Energy Engineers, and on the board of directors for the National Fenestration Rating Council and the Attachment Energy Rating Council.



Dr. Jason DeGraw

Dr. Jason DeGraw serves the BEC as a Technical Team Member. He is an R&D staff member in the Integrated Building Performance Group at ORNL. His research has focused on the numerical simulation of thermo-fluid flow phenomena at a variety of scales and in several different application areas. Dr. DeGraw holds a master's degree and a PhD in mechanical engineering from the Pennsylvania State University. His recent work in building performance simulation has applications in indoor air quality, building security, and resilience. Dr. DeGraw is a member of the EnergyPlus development team, DOE's flagship building energy simulation engine. He is also an active member of ASHRAE and the founding chair of the association's Technical Committee 2.10, Resilience and Security.



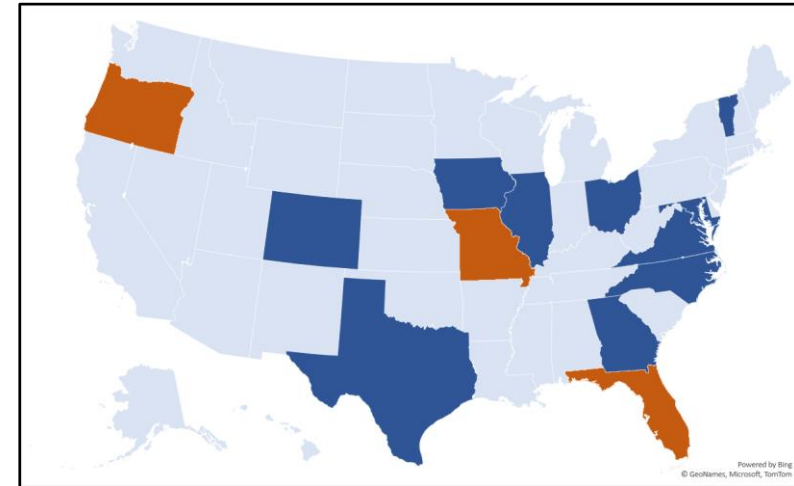
Dr. Antonio J. Aldykiewicz Jr.

Antonio J. Aldykiewicz Jr., LEED AP B+C, serves the BEC as a Technical Team Member. He is an R&D senior staff member in the Building Technologies Research Group at ORNL. He has more than 20 years of experience in research and product development of building materials used in residential and commercial construction. Dr. Aldykiewicz has developed products to improve the performance and durability of concrete, air, and vapor barriers for commercial construction; fire protection products to protect structural steel; and waterproofing materials for below-grade structures. His work has also involved the development and characterization of materials, composite systems, and assemblies including the implementation of finite element models to facilitate product development and large-scale structural testing. Dr. Aldykiewicz holds a PhD in materials science and engineering from the State University of New York at Stony Brook and an MBA from Babson FW Olin Graduate School of Business. He is a LEEDTM Accredited Professional Building Design+Construction engineer. Dr. Aldykiewicz is an active member of the Electrochemical Society, American Society of Testing and Materials, and American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Progress: Engagement & Performance metrics, FY 21 & FY 22

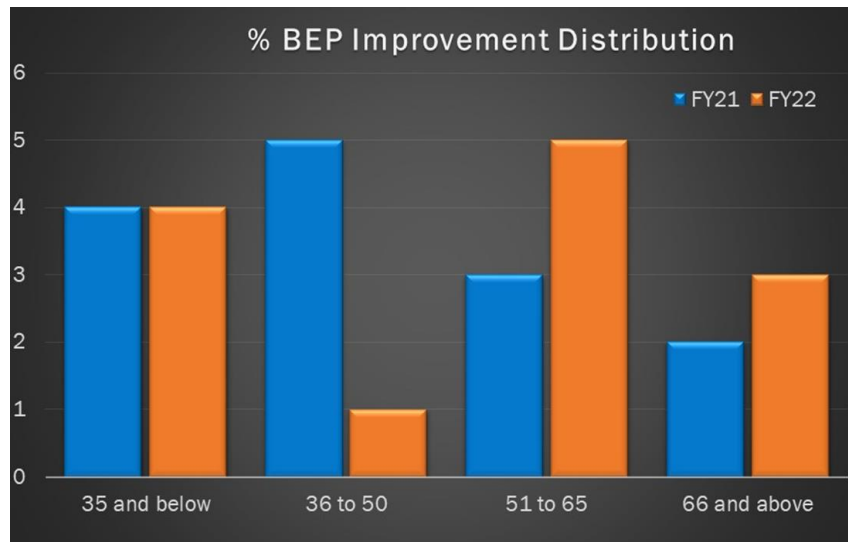
Engagement

- 30 submissions, retrofits & new construction across the U.S.
- Range of locations & building types: healthcare, education, commercial office space and industrial
- Envelope measures: increased insulation; air sealing; windows; secondary glazing; cool roof technologies



FY 21

FY 21 & FY 22



Performance metrics

- **Conditioned floor space (ft²) & Total energy savings, (Btu/year)**
 - FY 21, 1.5 million ft², 9 million Btu/year
 - FY 22, 2.0 million ft², 13 million Btu/year
- **Recognition & awards:**
 - FY 21, 14 buildings
 - FY 22, 13 buildings

Recognition Awards for FY 21 & 22

Buildings, FY 21

BCH Lafayette Community Medical Center	Novel 40
American Geophysical Union	Retro 50
Lubber Run Community Center	Novel 20
BVSD Education Center	Novel 40
Catalyst	Novel 40
Vergennes Community Housing	Novel 40
Credit Human Headquarters	Novel 40
Athens County EMS Station	Novel 40
Industrial Center Building Addition	Novel 20
Prairie Trails School	Retro 50
B246	Retro 30
ASHRAE World Headquarters	Retro 50
Plant Sciences Building	Novel 20
Vermeer - New Plant 7	Novel 20

Award

Buildings, FY 22

Shenandoah Valley Elementary School	Retro 30
Parkway West Middle School	Retro 30
Barretts Elementary	RHM
Pacific Tower	Retro 30
NC Environmental Quality Biochemistry Lab	Retro 50
James A Haley VA Main Hospital Building	Retro 50
James A Haley VA Research Building	Retro 50
James A Haley VA Community Living Center	Retro 50
James A Haley VA Radiation Therapy	Retro 30
James A Haley VA Specialty Clinics	Retro 50
James A Haley VA Administration Annex	Retro 30
Charlie Norwood VA Hospital	RHM
Laurentide Apartments	Novel 40/EE

Award

Example Awarded Projects: FY 21 & 22

FY 22, Laurentide Apartments, Burlington, VT
60% BEP improvement



FY 21, Boulder Valley School District Education Center, Boulder City, CO
46% BEP improvement

FY 22, James A. Haley Veterans Administration Hospital, Tampa, FL
62% BEP improvement



FY 21, American Geophysical Society, Washington, D.C.
50% BEP improvement

Alignment and Impact



Greenhouse gas emissions reductions

Supports the development and implementation of energy conservation measures that lead to reduction in carbon emissions, directly aligned with EERE/BTO goal to achieve Net Zero emissions by 2050. **The Building Envelope Campaign encouraged 22 buildings to participate in the campaign. The FY21 and FY22 campaigns resulted in emission avoidance of 4,620 metric tons of CO_{2eq}**



Power system decarbonization

BEC supports power system decarbonization by charting a course for building owners and managers to design energy efficient enclosures for new construction and make improvements to existing buildings that reduces demand on the grid. **The FY21 and FY22 campaigns resulted in energy reduction of just over 22 million kBtu/year.**



Energy justice

Support energy justice in underserved communities by addressing the performance of buildings such as affordable multi-family housing, schools and medical facilities that rely on public funding to operate. By lowering the cost of energy through implementation of high-performance envelope integration, public resources can shift from energy to other social services such as education, childcare, employment, and healthcare.

Future work

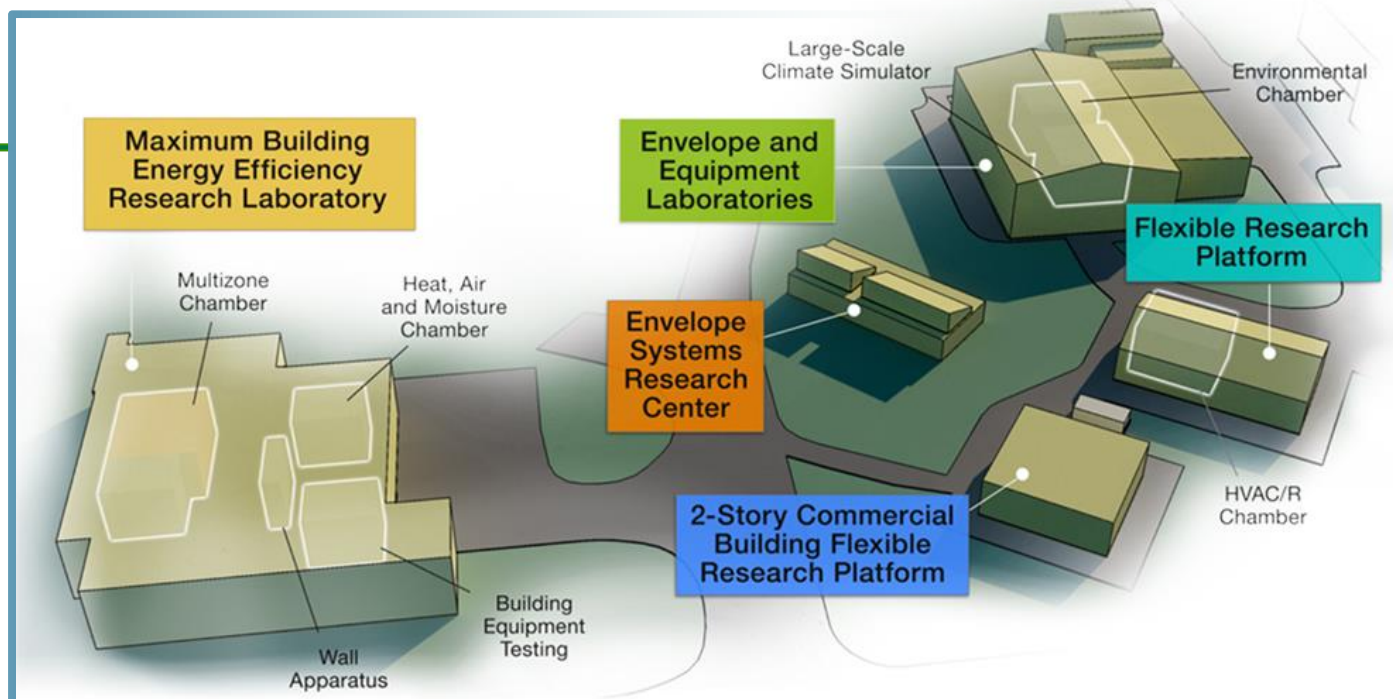
- **Continue encouraging and supporting participants**
- **Continue coordination with other BB Campaigns**
- **Review FY 23 submissions**
- **Select eligible awardees and award notifications**
- **Compile the energy savings data**
- **Webinar or in-person venue to recognize the awardee**
- **Campaign close-out**

Thank you

Oak Ridge National Laboratory

Mahabir Bhandari, R&D Staff

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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+ ft² 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***

Project Execution

	FY2021				FY2022				FY2023			
Planned budget	300				300				300			
Spent budget	300				300				300			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work												
Q1 Milestone: Launch FY 21 campaign, outreach and support	■	◆										
Q2 Milestone: Outreach, support and submission reviews		■	◆									
Q3 Milestone: Review submissions & compile metrics			■	◆								
Q4 Milestone: Award recognition & FY21 campaign closeout				■	◆							
Q1 Milestone: Launch FY 22 campaign, outreach and support					■	◆						
Current/Future Work												
Q2 Milestone: Outreach, support and submission reviews						■	◆					
Q3 Milestone: Review submissions & compile metrics							■	◆				
Q4 Milestone: Award recognition & FY22 campaign closeout								■	◆			
Q1 Milestone: Launch FY 23 campaign, outreach and support									■	◆		
Q2 Milestone: Outreach, support and submission reviews										■	◆	
Q3 Milestone: Review submissions & compile metrics											■	◆
Q4 Milestone: Award recognition & FY 23 campaign closeout												■

REFERENCE SLIDES

How do we get there?

SUPPORTER

Supporters (manufacturers, researchers, utilities, industry organizations, etc.) are invested in the campaign even though they may not be able to submit buildings for recognition.

As a supporter, you will be able to:

- ▶ Access technical expertise regarding envelope technologies
- ▶ Partner with the BEC technical team to promote the campaign
- ▶ Receive public recognition for your support

PARTICIPANT

Participants (building owners/managers, architects, general contractors, consultants, etc.) will be given access to campaign resources—including the building assessment tool—and technical expertise in evaluating envelope options.

As a participant, you will have the opportunity to:

- ▶ Be publicly recognized for your participation
- ▶ Stay informed of envelope technologies and resources produced through the campaign
- ▶ Collaborate with the BEC in the development of case studies

Supporters

Supporters include manufacturers, researchers, utilities, and industry organizations. They do not own or manage buildings directly but are invested in the Campaign and the mission to improve building envelope performance. Supporters serve as invaluable amplifiers of the Campaign, leveraging their networks to promote the Campaign and recruit new Participants. Organizations may also start as a Supporter and transition to a Participant anytime!

- A. David Gibson Architect, LLC
- AeroBarrier / AeroSeal
- Air Barrier Association of America
- Alliance Center
- Alpen High Performance Products
- American Primitives
- Arc Green Consultant
- ARES Consulting
- Arkema Inc.
- BA Consult
- Barnhardt MFG dba NCFI Polyurethanes
- Becker Morgan Group, Inc.
- Brandeis University
- Building Performance Architecture
- CalBarrier, LLC
- Cameron Building Envelope Specialists
- Canam Building Envelope Specialists/WTI
- Carlisle Construction Materials
- Central Maine Community College
- Cova Green Homes
- Dekker / Perich / Sabatini
- EIMA
- Entegriety
- EPS Industry Alliance
- Fabreeka International, Inc.
- Fanning Howey
- Floe, Inc.
- Gale Associates Inc.
- GE Silicones (Momentive Performance Materials)
- Geissler Roofing Co Inc
- Ghafari Associates
- IBACOS
- Indow
- Inovues
- Johns Manville
- KARNAK
- Los Alamos National Laboratory
- Lawrence Berkeley National Laboratory
- Mathis Consulting
- MaxLife Industries
- Miami Dade Water & Sewer Dept.
- National Fenestration Rating Council
- National Institute of Building Sciences
- National Renewable Energy Laboratory
- Neudorfer Engineers
- New Buildings Institute
- Newmark Knight Frank
- NEXUSbec, inc.
- North American Insulation Manufacturers Association (NAIMA)
- North American Passive House Network
- Northwest Energy Efficiency Alliance (NEEA)
- NRG Insulated Block
- OAC Services, Inc.
- Owens Corning
- Particle Works Incorporated
- Power Shield, Inc.
- PROSOCO, Inc.
- Renovate by BERKOWITZ
- Rethinking Power Management, LLC
- Scales Development, Inc.
- Shadid MARKET(ing) Consulting
- Shiv Architecture P.C.
- SIGA
- Smart Energy Design Assistance Center, University of Illinois (SEDAC)
- SOPEC - Sustainable Ohio Public Energy Council
- SOPREMA
- Spray Polyurethane Foam Alliance
- Storm Windows and Insulating Panels Campaign (SWIP), DOE/PNNL
- Structural Insulated Panel Assn. (SIPA)
- Sunshine Sustainable Design
- ThenDesign Architecture
- Transduction Technologies
- Tremco Commercial Sealants & Waterproofing
- Tremco Construction Products Group
- University of Maryland
- US Ecologic
- US Greenfiber LLC
- Walter P. Moore
- Western Specialty Contractors
- Window Film Depot
- York Flashings

Participants

Participants can be building owners and managers or their contractors, such as architects, general contractors, and consultants. Participants use the building envelope assessment tool to determine their building's Building Envelope Performance value and identify areas of potential improvement. Participants may apply for and receive recognition annually - eligible buildings include new construction or retrofit commercial (or multifamily residential) buildings in the United States that have been completed since January 2019.

- Active Zero Energy Bandwagon, Inc
- Advanced Enclosure Consulting, LLC
- AINA Dev, LLC
- Allana Buick & Bers, Inc
- American Geophysical Union
- Arlington County Department of Environmental Services
- ASHRAE
- Athens County
- Avery Dennison
- Baseys Roofing & Sheet Metal
- Better Building Works LLC
- BG3 Architecture, LLC
- Bio Energy Strategies and Tactics
- Boulder Associates
- Boulder Valley School District
- Building Enclosure Consultants, Inc.
- Building Optimization Technology, LLC
- Bullitt County Public Schools, Kentucky
- City of Alexandria, Virginia
- City of Grand Rapids
- CLEARResult, submitting on behalf of ComEd
- Community College of Allegheny County
- Credit Human Federal Credit Union
- Design Innovation Architects
- Educational Opportunities for Children and Families
- Engineers
- eSai LLC
- Evernorth
- EYP Architecture & Engineering
- Fair Building Technology LLC
- FGM Architects
- Flad Architects
- Fulton County Schools
- GLHN Architects & Engineers, Inc.
- GS Research LLC
- Hempitecture
- Houston Advanced Research Center (HARC)
- H2M architects + engineers
- IMPACT Industrial Services
- Indy Ypsi Properties, LLC
- Judicial Council of California
- Mass General Brigham
- Massport
- Melrose Energy Commission
- McKinstry
- Mercury Solar
- Metropolitan Government of Nashville & Davidson County
- Murphy's CELL-TECH LLC
- North Carolina Department of Environmental Quality
- Parkway School District
- PassiveHouse BB
- Perkins Eastman Architects
- RDH Building Science Inc.
- Redhorse Corp
- River Trails School District 26
- Robert Clarke Associates, LLC
- RWDI
- Sandhill O'Farrell LLC
- Tenderloin Neighborhood Development Corporation
- Timber Block USA, Inc.
- VA Tampa Health Care | Veterans Affairs
- VHA Energy Engineer's Advisory Board
- Vitro Architectural Glass
- West Penn Power Sustainable Energy Fund

Technical Team



Gina K Accawi
Group Leader, Digital
Manufacturing and
Analyses
Frameworks



Jason DeGraw, PhD
R&D Staff Member,
Building Integration
Group



Mahabir Bhandari, PhD
R&D Staff, Building
Envelope & Urban
Systems Research
Group



Kuma Sumathipala,
Ph.D., P.Eng.,
Integrated Building
Deployment and
Analysis Group



Antonio Aldykiewicz Jr, Ph.D.,
Senior R&D Staff,
Building Envelope Materials
Research Group