



# Reducing Energy Consumption: Innovations in the Built Environment

Connected Communities Webinar Series

January 14, 2025



# Welcome

- The Latest From Connected Communities
- Topics & Panelists
  - Integrated Retrofit Solutions
    - **Diana Hun**, Group Leader in Building Envelope Material Research, Oak Ridge National Laboratory
  - Introduction to Passive Buildings
    - **Joshua Prichard**, Associate Principal, Centric Architecture
  - Living Buildings: Case Study
    - **Catey McClary**, President and CEO, Great Smoky Mountains Institute at Tremont
- Panel Discussion
- Close Out

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# The Latest From Connected Communities

# Connected Communities Initiative

We're helping communities embrace technology and data solutions to overcome their challenges and prepare to be part of the energy system of the future.

## FOCUS AREAS



**Broadband and Digital Literacy**



**Economic Empowerment**



**Energy and Environmental Justice**



**Enhanced Community Resiliency**

## RESOURCES



**Community Information Hub and Website**



**Tailored Support and Success Coaching through Partnerships**



**Pilot Project Funding**



**Network to Share Information and Success Models**



# Upcoming Webinar

Identifying Your Opportunity:  
Innovations in Workforce Development

Tuesday, February 11, 1:00 – 2:00 pm ET

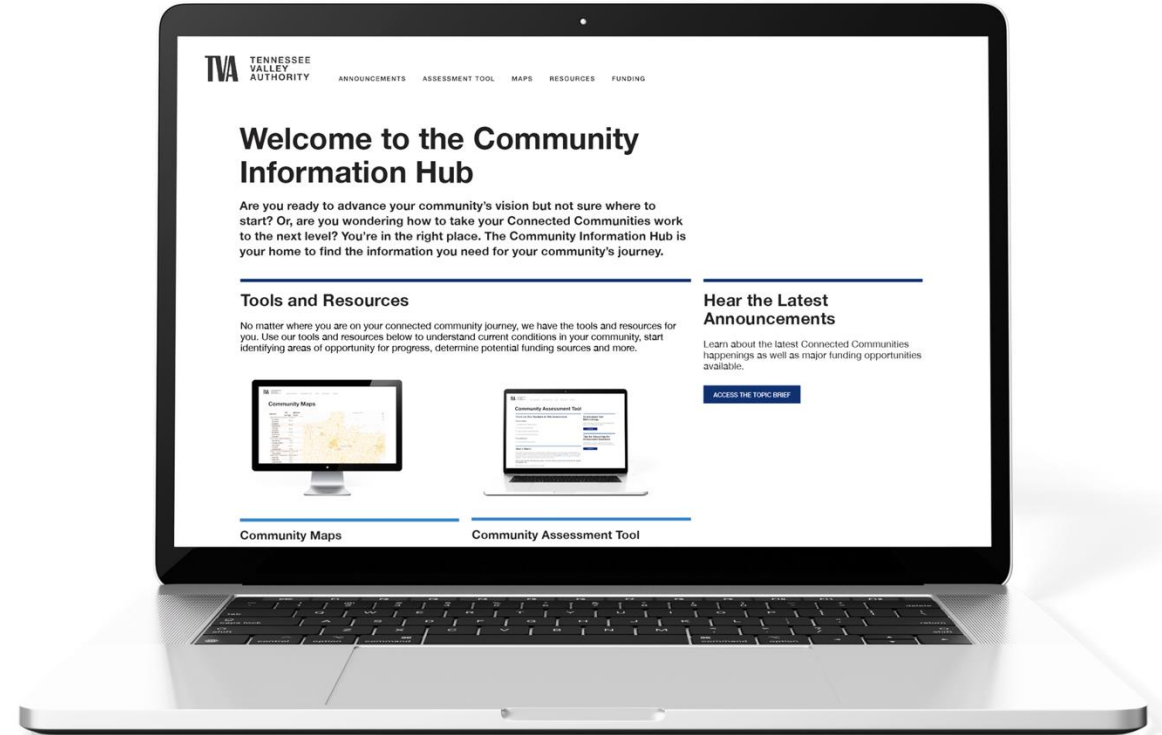


REGISTER NOW



# Community Information Hub

A new, interactive tool is available to help **assess your community needs, prioritize solutions and identify funding opportunities.**



2<sup>ND</sup> ANNUAL

# TVA Connected Communities Conference

**Empowering Connections:**  
Building Stronger Communities Together

**Location:** Murfreesboro, TN

**Date:** October 21<sup>st</sup> – 22<sup>nd</sup> 2025



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# Innovations in the Built Environment



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# Meet Today's Speakers



**Diana Hun**

Group Leader in Building  
Envelope Material Research,  
Oak Ridge National Laboratory



**Joshua Prichard**

Associate Principal, Centric  
Architecture



**Catey McClary**

President and CEO, Great  
Smoky Mountains Institute at  
Tremont

# Integrated Retrofit Solutions

TVA Connected Communities Webinar  
January 14, 2025

Diana Hun, PhD, PE (inactive)  
Group Leader | Building Envelope Materials Research  
Subprogram Manager | Building Envelopes

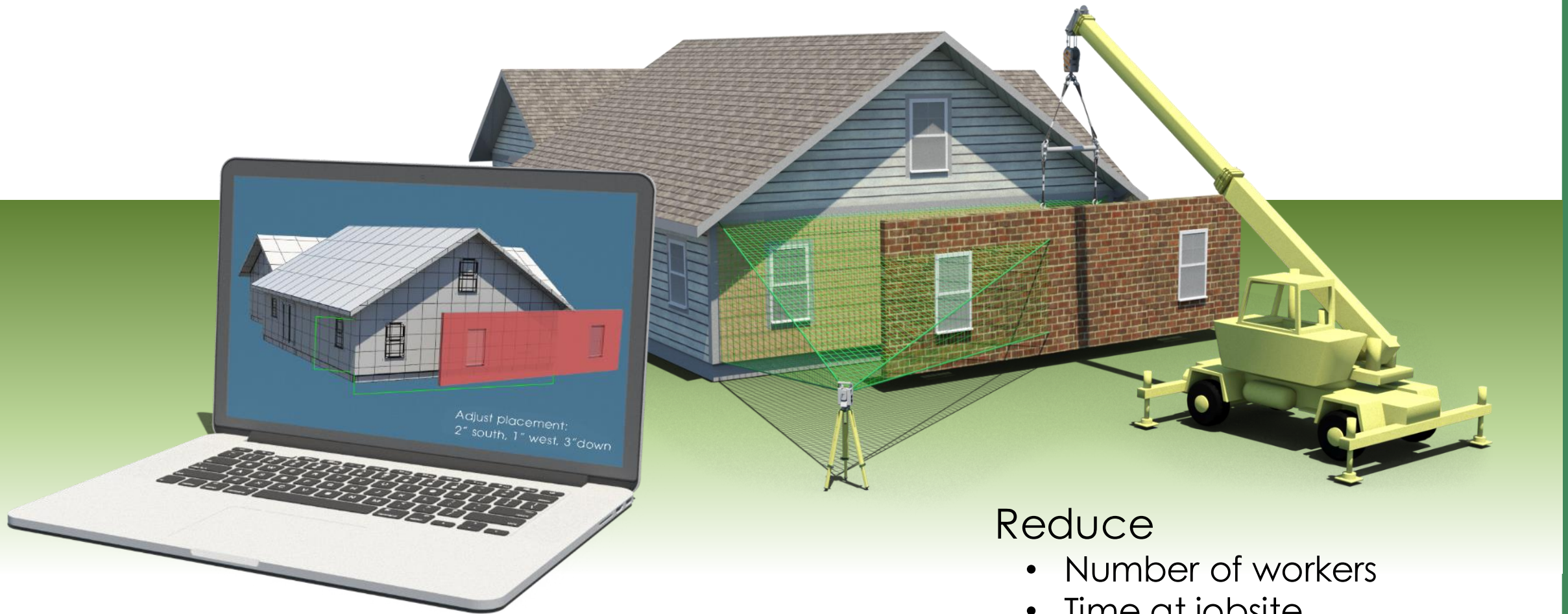
ORNL is managed by UT-Battelle, LLC for the US Department of Energy



## Importance of envelope retrofits

- ~50% of existing buildings were built before there were energy codes
- The envelope is among the most difficult building components to retrofit
  - Intrusive
  - Disruptive
  - Slow
  - Costly
- Less than 2% of residential envelopes are retrofitted each year

# Prefab Overclad Panels



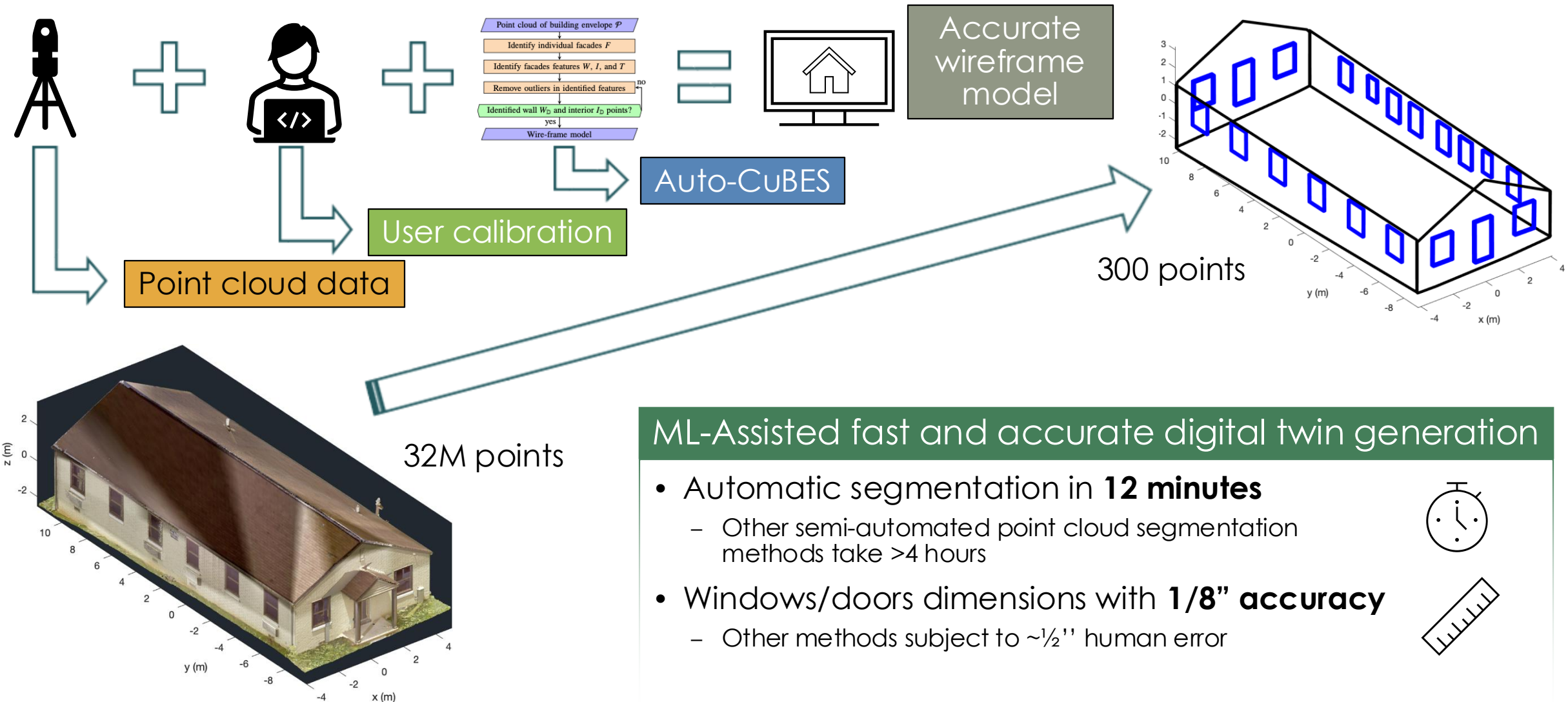
## Reduce

- Number of workers
- Time at jobsite
- Occupant disruption
- Waste at jobsite

# Digital Twin of Existing Building

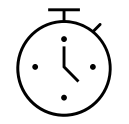


# Auto-CuBES: Automatic point Cloud Building Envelope Segmentation



## ML-Assisted fast and accurate digital twin generation

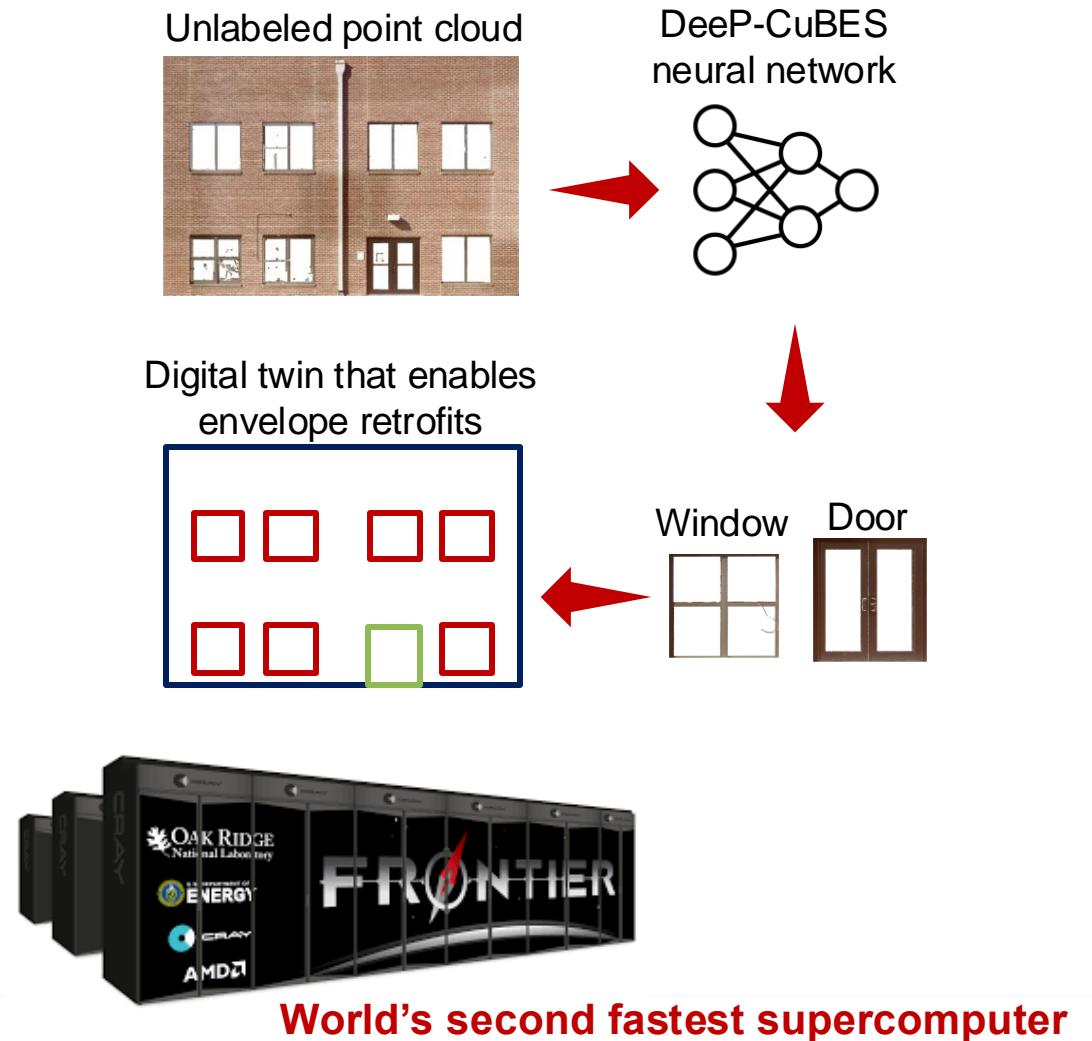
- Automatic segmentation in **12 minutes**
  - Other semi-automated point cloud segmentation methods take >4 hours
- Windows/doors dimensions with **1/8" accuracy**
  - Other methods subject to ~1/2" human error



Maldonado et al. Automatic point Cloud Building Envelope Segmentation (Auto-CuBES) using Machine Learning. Int. Symp. Automation and Robotics in Construction, 2023.

# DeeP-CuBES: Deep learning for Point Cloud Building Envelope Segmentation

- Automatic segmentation of point cloud data to generate a digital twin
  - <1 minute
  - Accuracy of 1/8 inch
- Train supervised deep neural network w/ accurate labeled training data
- Use ORNL's Frontier supercomputer to reduce training time of deep neural networks by a factor of 100



**World's second fastest supercomputer**

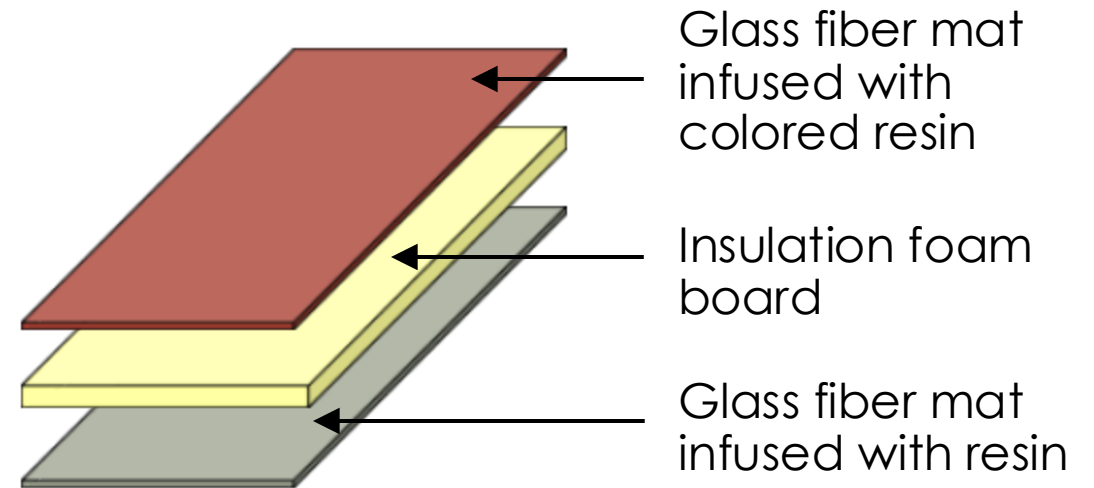
# Overclad Panels





## Lightweight, Composite, Overclad Panels

- Fiber reinforced composite facers
  - Fibers infused with colored resin or incorporate a textile before infusion
- Structural capacity easily tailorable
  - Change amount of fiber reinforcement
  - May not need to increase panel thickness
  - Can be designed for flexure and axial loads



# R30 Panel Comparison

Feature	Wood Framing Readily Available	Synthetic Stucco Readily Available	Fiber Reinforced Composites (ORNL)
Weight (psf)	~5.2	~5	~3.5
Thickness (in)	~6.5	7.8	~5
Max panel size (ft×ft)	10+ × 40+ (restricted by shipping)	8 × 12	10+ × 40+ (restricted by shipping)
Customizable panel shape	Yes	Yes	Yes
Cutttable after assembly	Yes	Synthetic stucco may crack	Yes
Applicable to walls and roofs	Yes	No	Yes
Increase load capacity w/o increasing thickness	No	No	Tailor fiber reinforcement
Load bearing walls in new construction	Yes	No	Yes

## Ongoing tests

- Flammability
- Accelerated aging
- Air and water penetration
- Exposure to outdoor conditions

# Real-Time Feedback during Installation



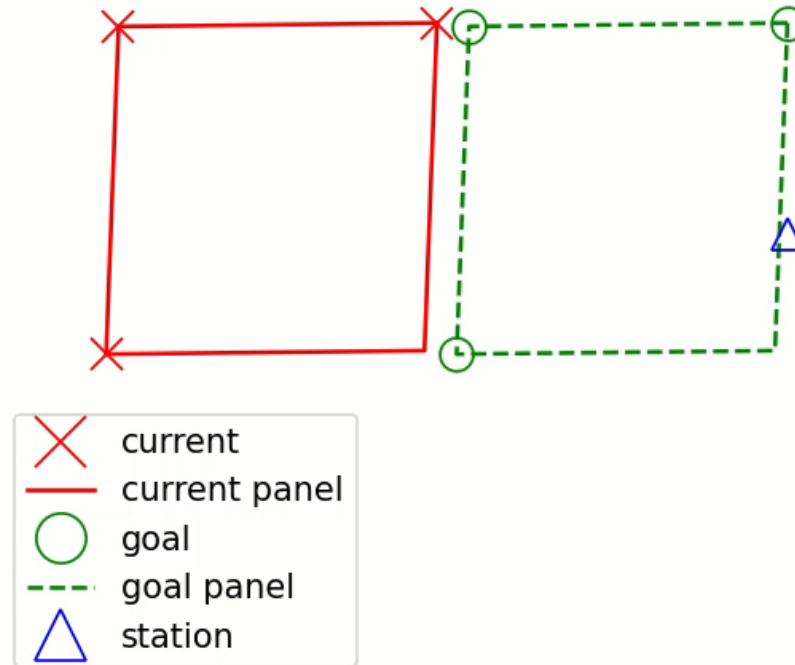
# Real-Time Evaluator (RTE)

Real Space



<https://www.ornl.gov/news/evaluating-buildings-real-time>

# Real-Time Evaluator Proof of Concept



Move	right 732	mm
Move	towards 266	mm
Move	down 0	mm
Rot. x	0	deg
Rot. y	0	deg
Rot. z	0	deg

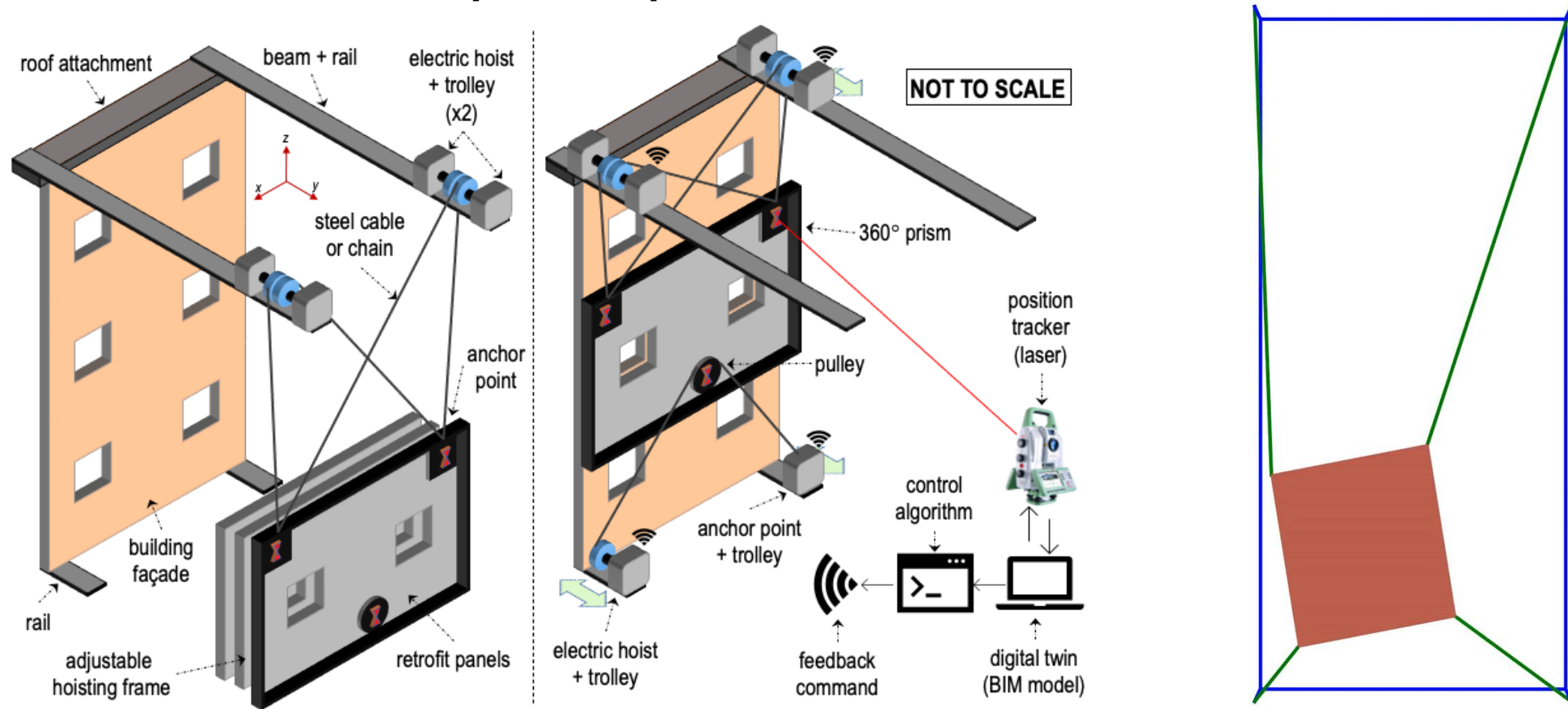


# Automated Overclad Panel Installation



# Fast, **A**ccurate, **M**inimally Intrusive (FAMI) Installation System

## Early Concept



- Portable and compact (sidewalk size)
- Avoids cranes and scaffolding
- Reduces errors
- Increases safety

# Deployment





# Reducing the Energy Burden of Low-Income Housing



KCDC provides housing options in Knoxville that meet the needs of families, seniors and disabled low-income residents.

**Before retrofit**



- Duplexes built in the 1940s
- Minimal thermal insulation
- Leaky envelope

**After retrofit rendering**



- Retrofit package will reduce thermal loads by at least 75%
- Retrofits will begin in 2025

**Secretary Granholm at retrofit site**



*This is hugely important because people who are in low- and moderate-income homes have the highest energy burden*



Diana Hun, [hunde@ornl.gov](mailto:hunde@ornl.gov)



# Phius 101

*Introduction to Passive Building and Phius Certification*

# DISCUSSION POINTS

**Point 1** – Why is Passive Building needed?

**Point 2** – What is Passive Building?

**Point 3** – What are the Benefits of Passive Buildings?

**Point 4** – What are the Challenges of Passive Building?

# DISCUSSION POINTS

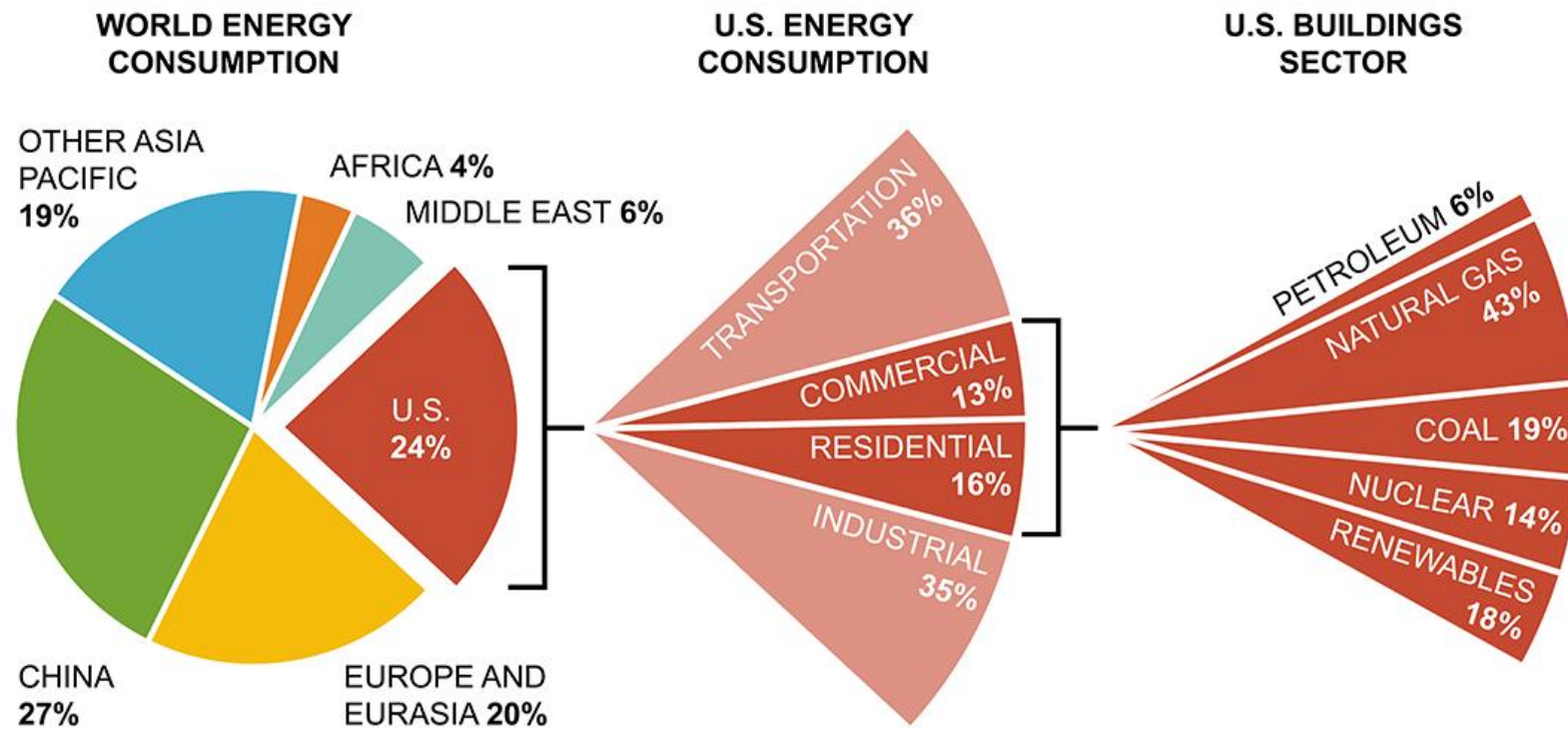
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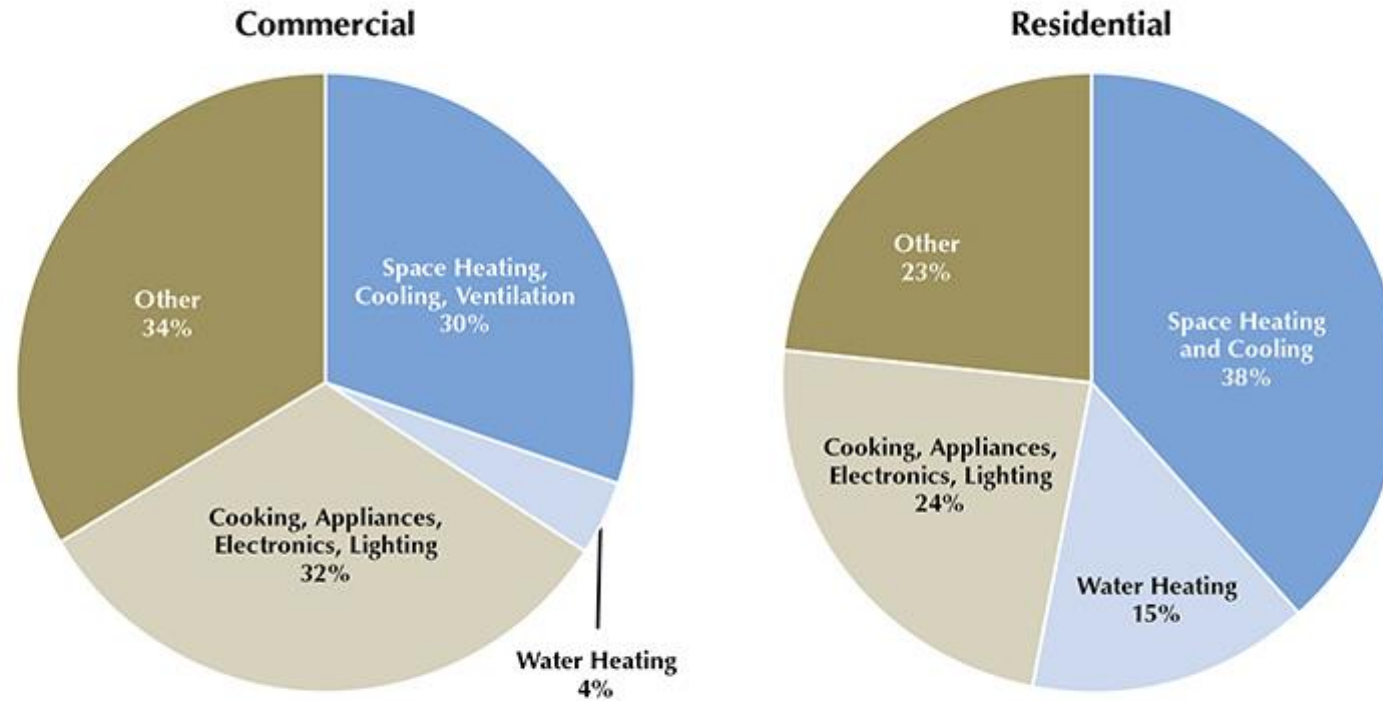
Point 4 – What are the Challenges of Passive Building?

## Energy Resources as Consumed by Various End-Use Sectors in the United States



Sources: U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2023) and *International Energy Outlook* (October 2023).

**FIGURE 1: Total CO<sub>2</sub> Emissions from the Commercial and Residential Sectors (2016)**



“Other” in both the commercial and residential sector includes items such as data servers, medical imaging equipment, ceiling fans, and pool pumps which are categorized as “miscellaneous electric loads” by EIA.

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018 (Washington, DC: U.S. Department of Energy, 2018), <https://www.eia.gov/outlooks/aeo>.

# DISCUSSION POINTS

Point 1 – Why is Passive Building needed?

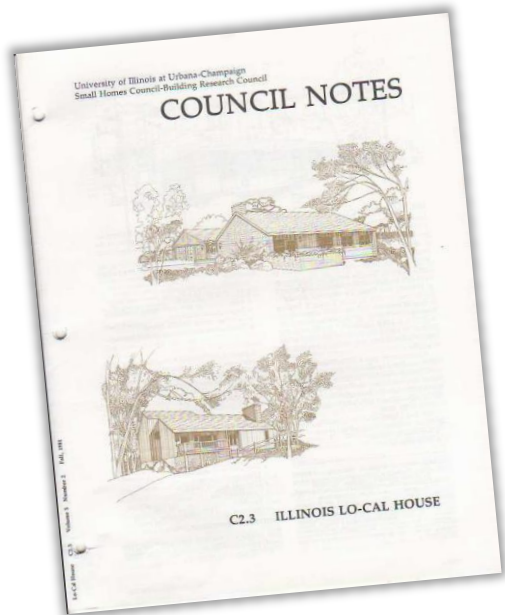
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# Passive Building Standards – History And Evolution



First energy reduction targets established  
Canada/US: 15% of typ. heating load

First experimental Lo-Cal Homes in Urbana IL

1974-76



1977-86



Passivhaus Standard pass/fail targets for Germany

1996

Swiss create Minergie-P etc.

2002

First project outside Europe to apply targets



2015-Present

Phius 2015/2018/2021 Climate & Cost optimized North America

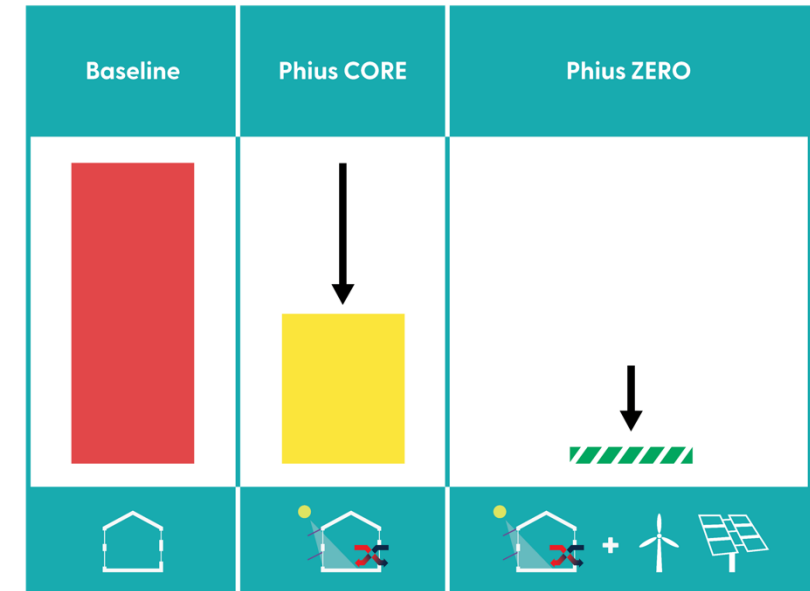


# First Passive, then Zero

**Step 1** - Conservation - first through passive measures, then through active measures.

**Step 2** – Renewable Energy - On-site or off-site renewable energy to offset remaining energy use.

With reduced loads, less renewable energy is needed, and less grid support is needed when the building isn't powered by renewable energy production.

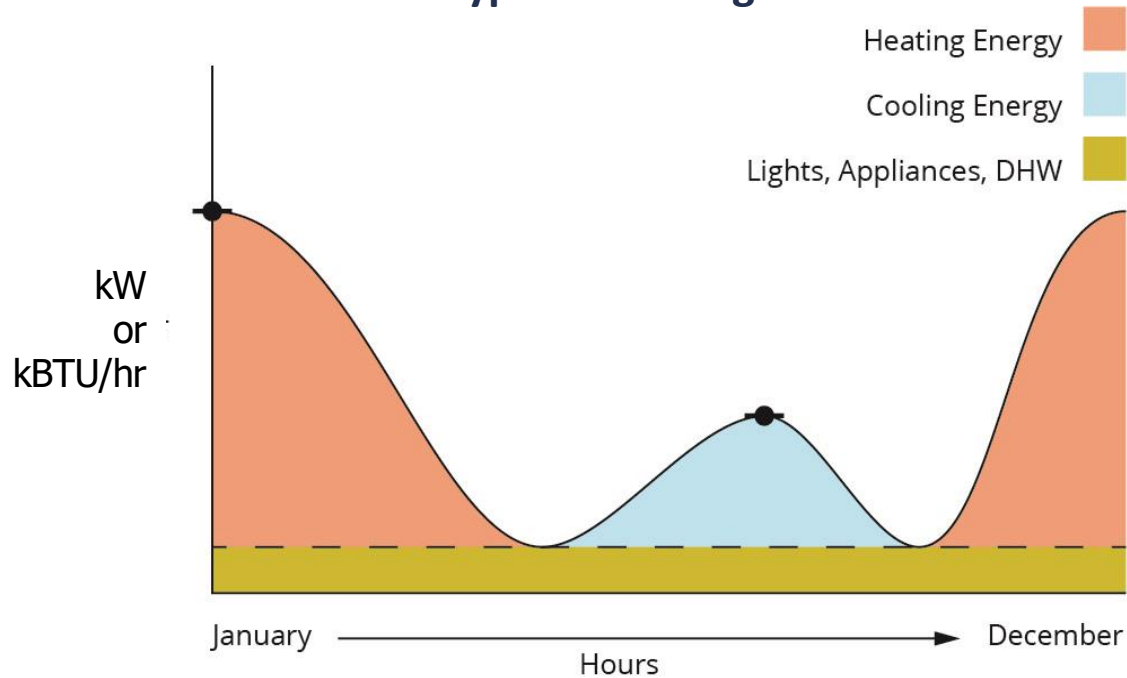


**Conservation efforts up-front will be critical for the wide-spread facilitation of Net Zero buildings into the existing electric grid.**

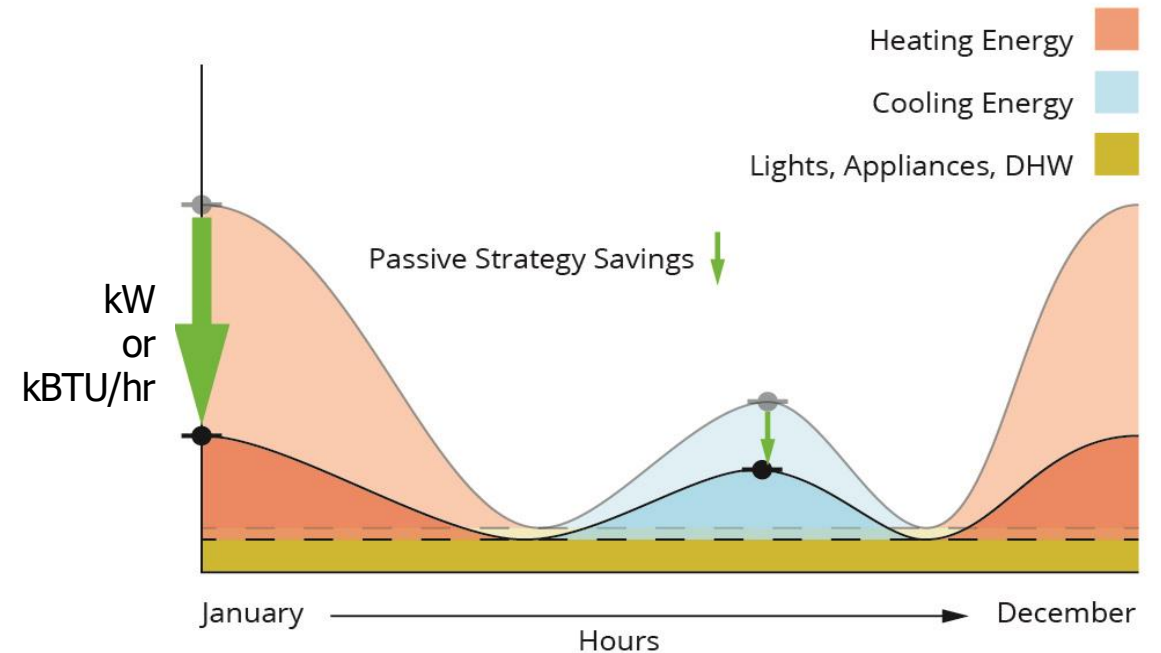


# What is Passive Building?

## Typical Building



## Passive Building



**Annual Energy** = kWh/yr (or kBTU/yr) → area under the curve

**Peak Power** = kW (or kBTU/hr) → point at top of curve

# Passive Building Principles

## THERMAL CONTROL



High  
Performance  
Insulation



Thermal Bridge  
Elimination

## AIR CONTROL

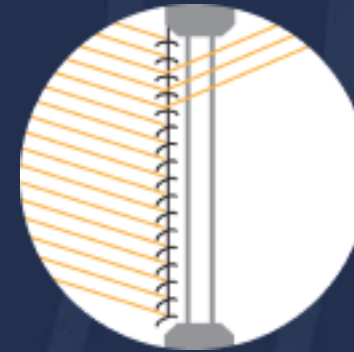


Air-Tightness



Enthalpy  
Recovery  
Ventilation

## RADIATION CONTROL

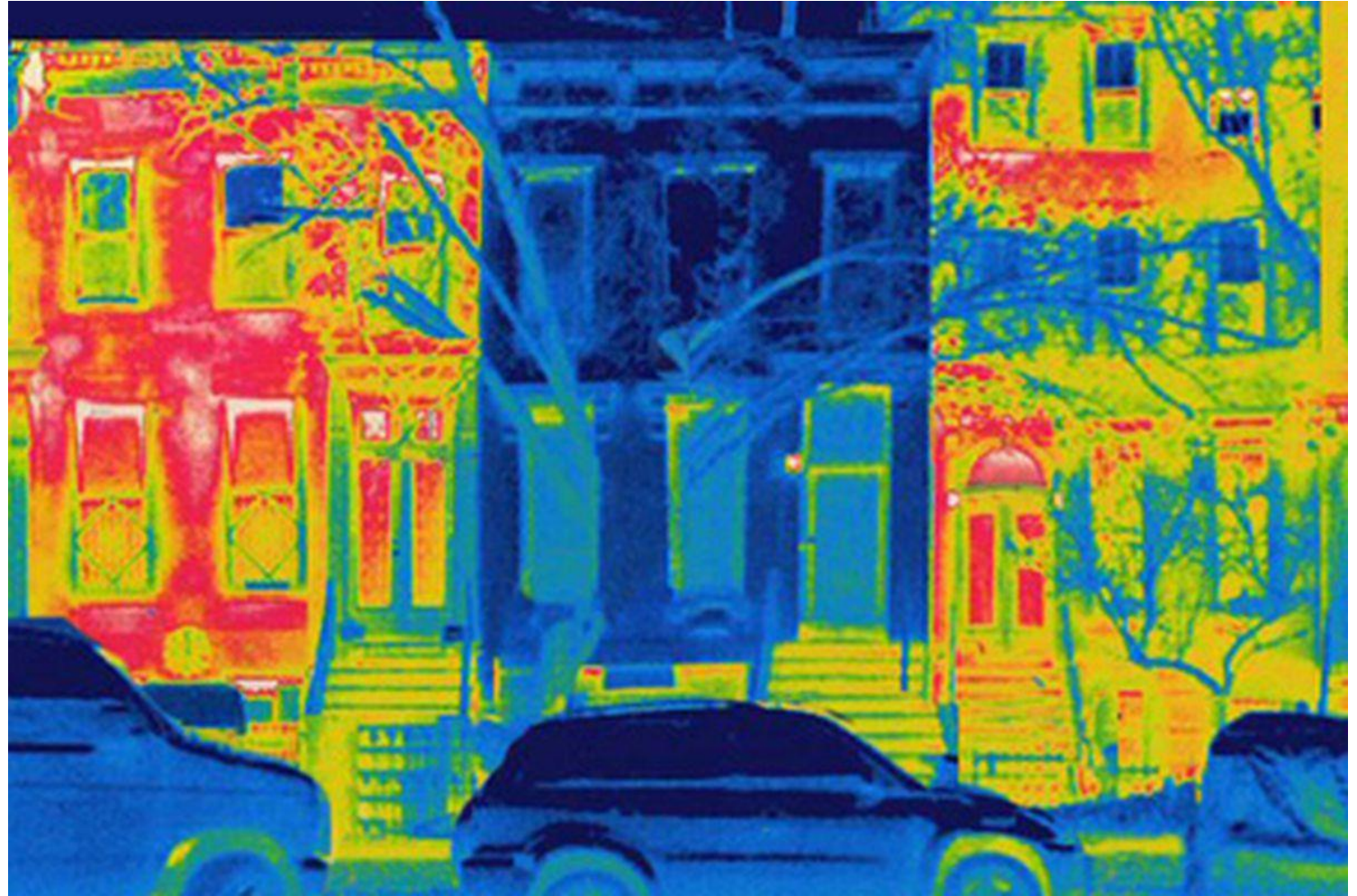


Shading /  
Daylighting



Climate  
Appropriate  
Glazing

# CONTINUOUS INSULATION

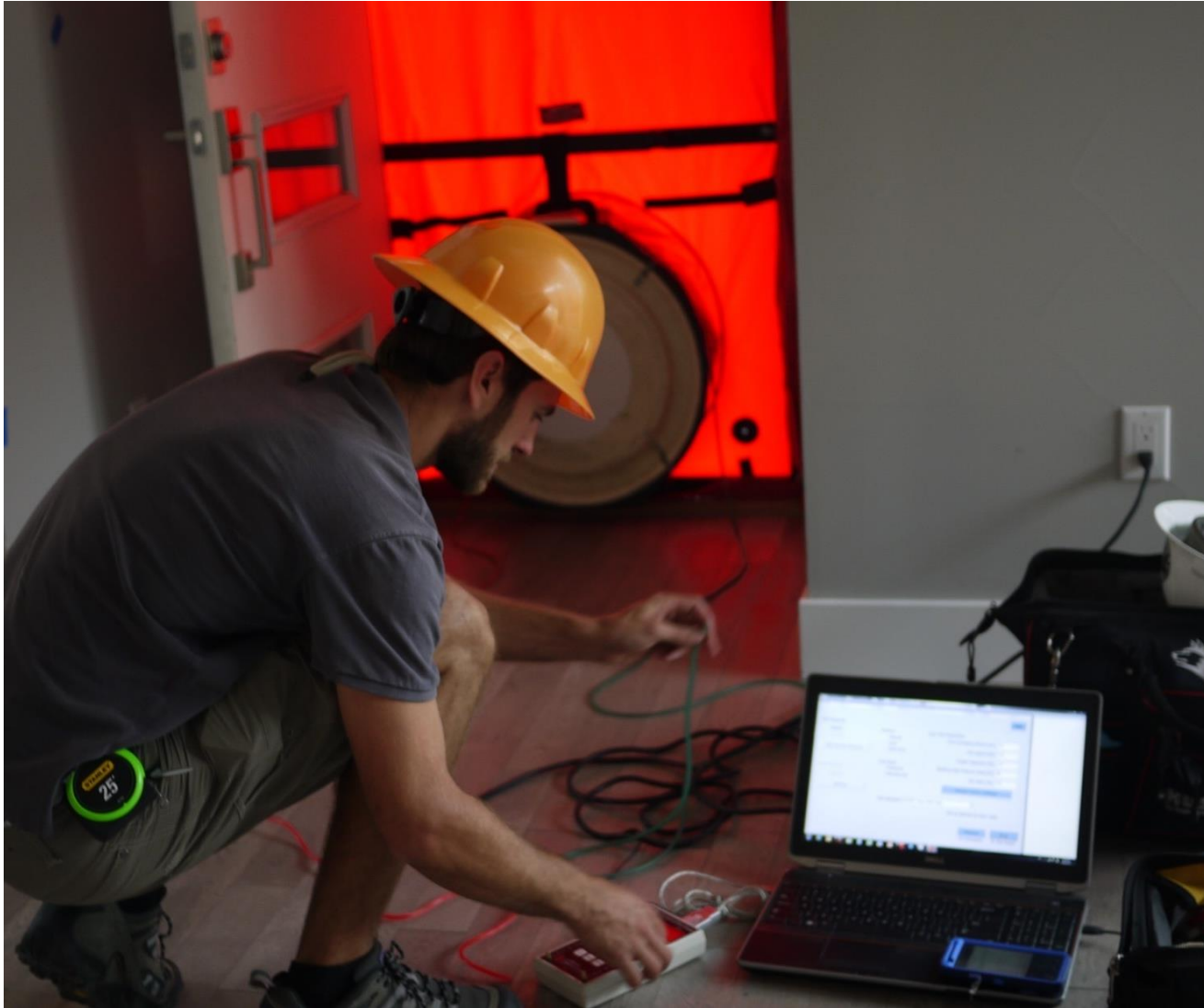




# THERMAL ENVELOPE



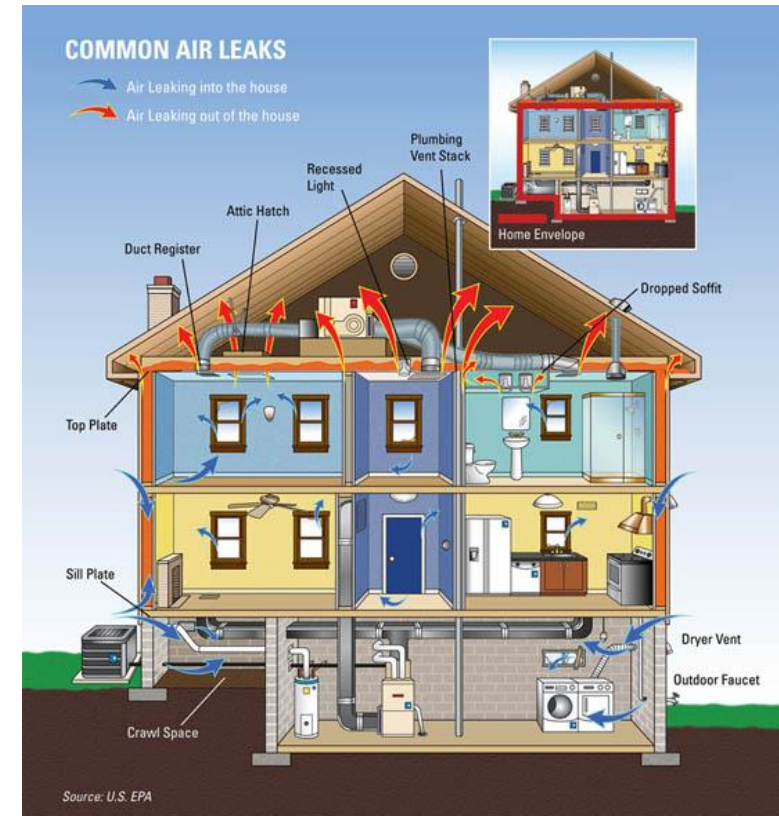
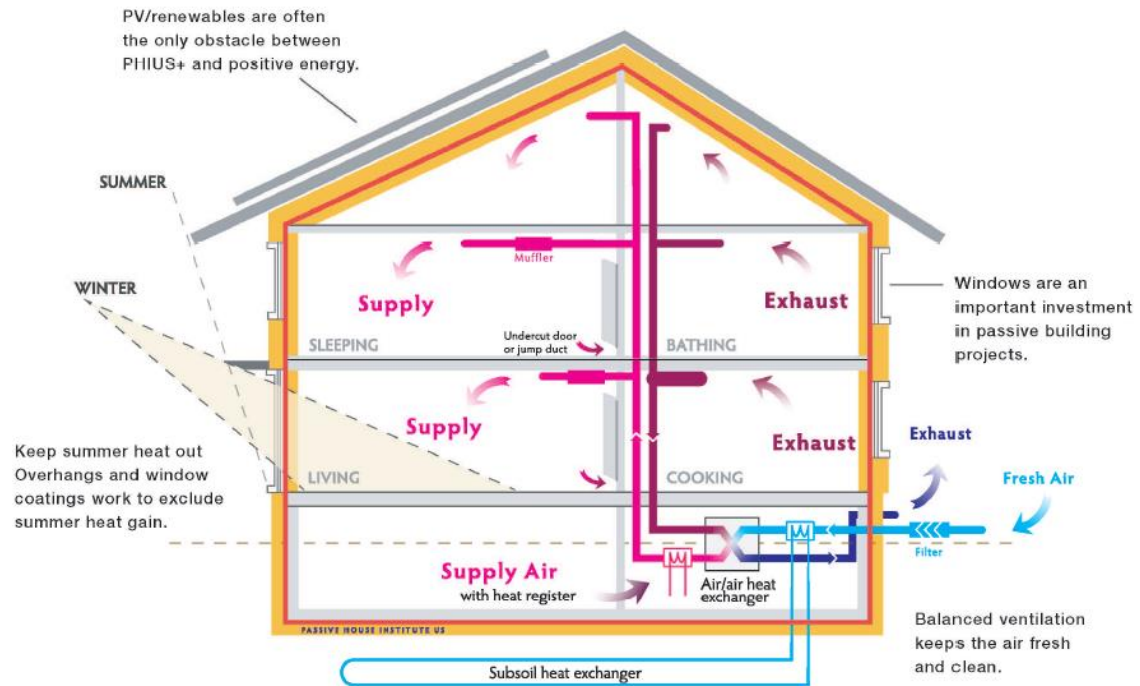
# AIRTIGHT CONSTRUCTION



*Phius 2021  
requirement is **5x**  
lower than  
building code  
(IECC 2021)*

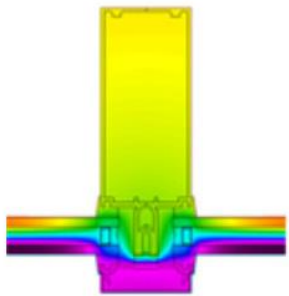
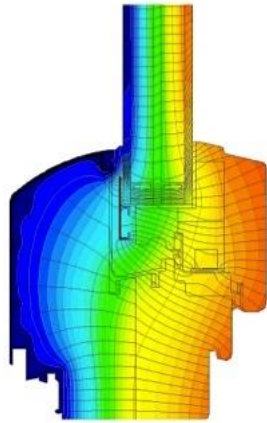
# BALANCED VENTILATION

## Controlled Ventilation vs Random Ventilation





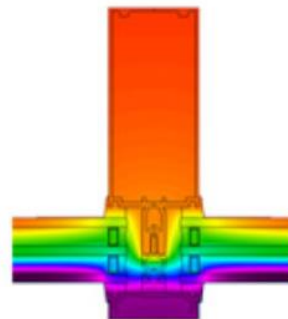
# OPTIMIZED WINDOWS



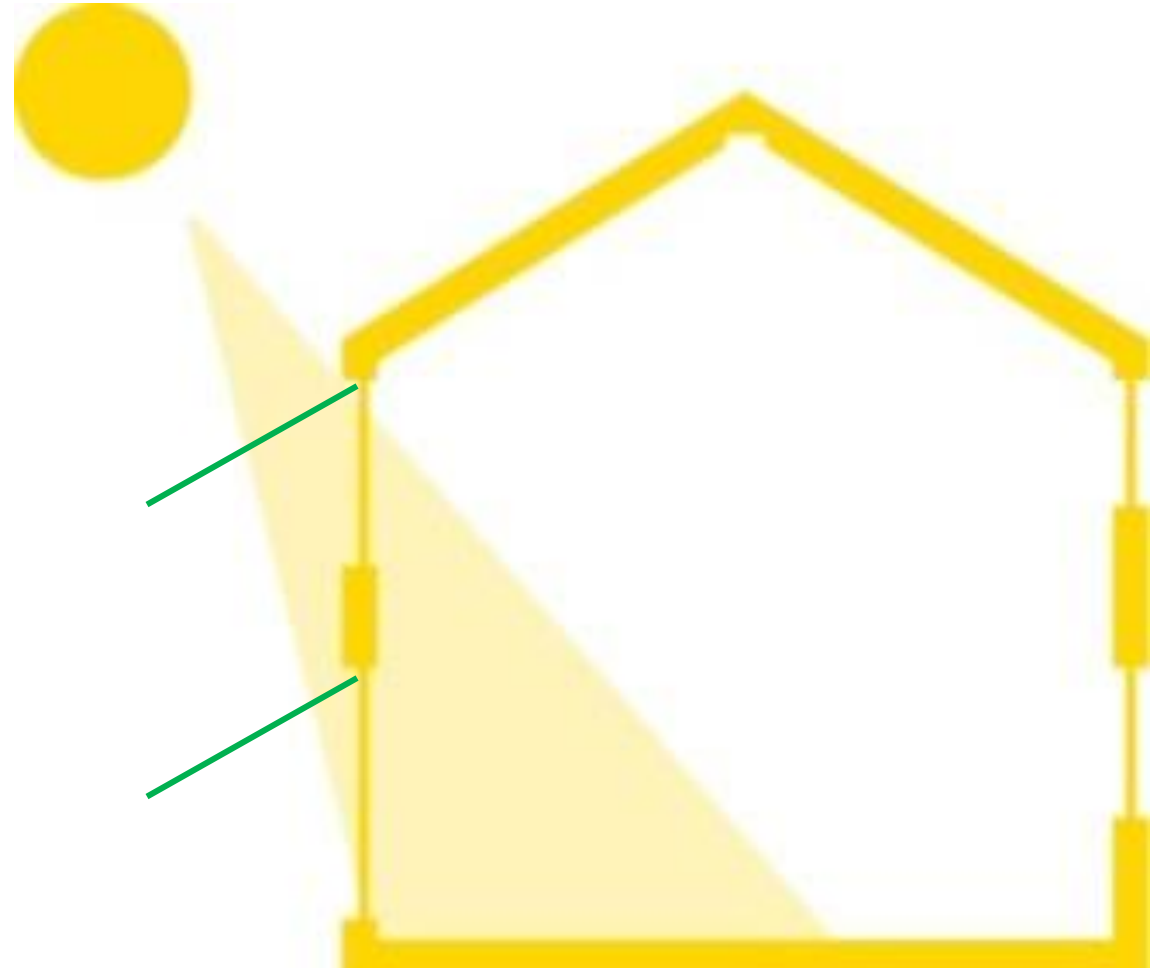
1600 Wall System@1  
1" Insulating Glass



1600UT Wall System@1  
1" Insulating Glass



1600UT Wall System@1  
1-3/4" Insulating Glass



# MINIMIZED MECHANICAL SYSTEMS



# DISCUSSION POINTS

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Point 2 – What is Passive Building?

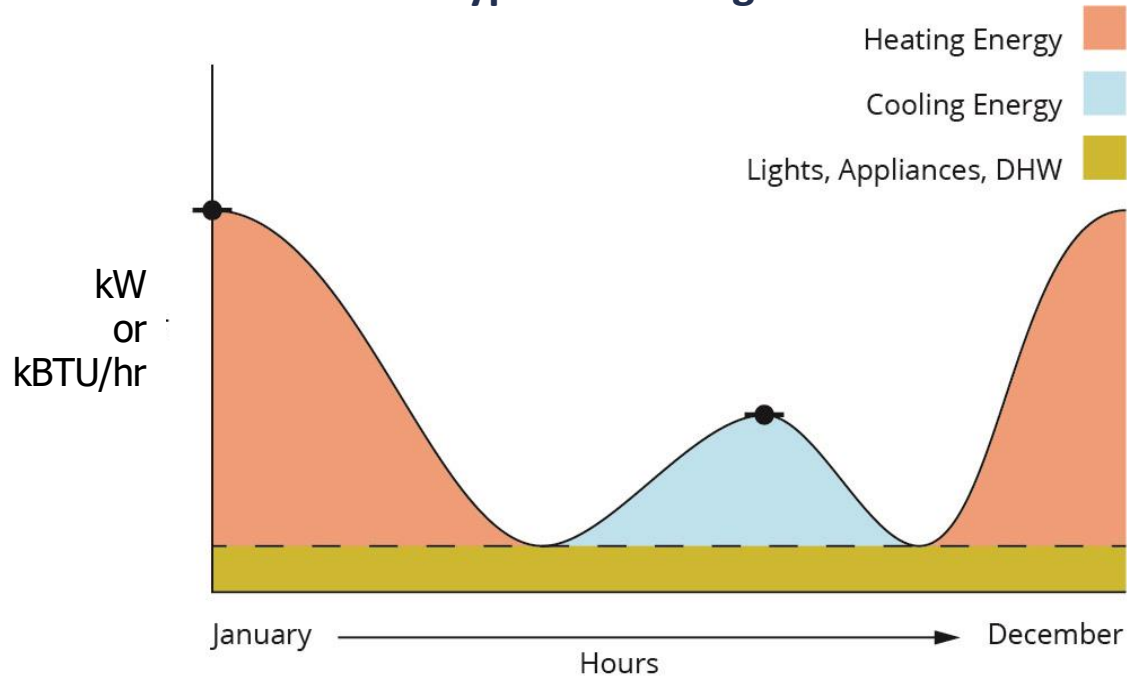
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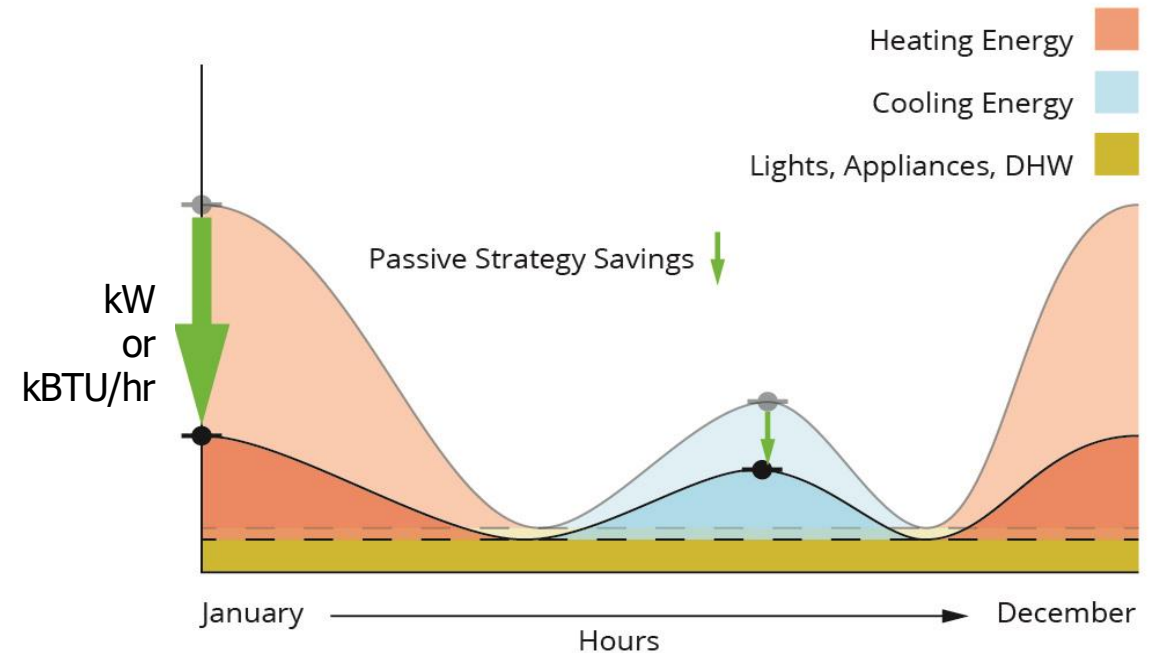


# 40-60 % Energy Savings

### Typical Building



### Passive Building



**Annual Energy** = kWh/yr (or kBTU/yr) → area under the curve

**Peak Power** = kW (or kBTU/hr) → point at top of curve

# Passive Building Delivers

**Healthy Interior**



**Comfort**



**Long-Term Affordability**



**Safety**



**Durability**



**Resilience**



# DISCUSSION POINTS

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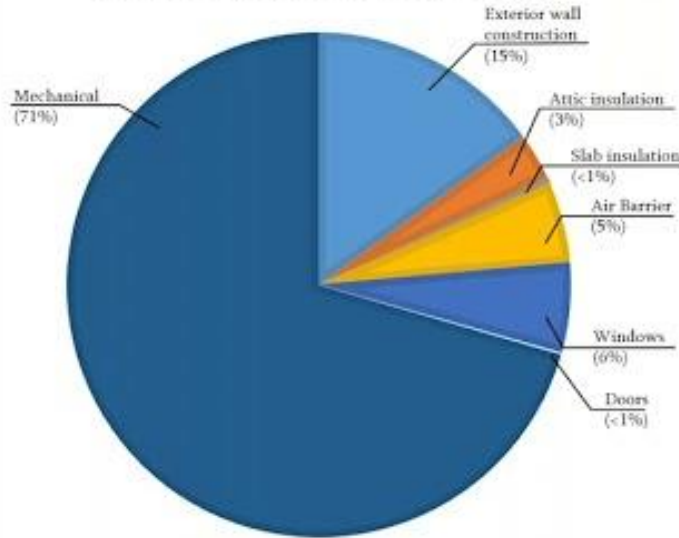
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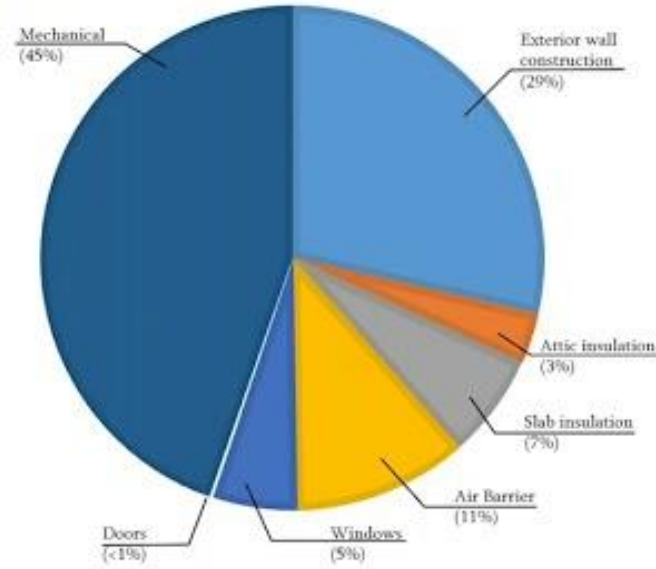
# Where is the money going...

### CHFA CONSTRUCTION COSTS



More money spent on **evolving** mechanical systems that have a **Shorter** Life Cycle

### PHIUS CONSTRUCTION COSTS



More money spent on the **static** Building Envelope that has a **Longer** Life Cycle



# Assembling a Team



- Required
- Involved Early
- Energy Modeler
- Verifies compliance throughout design
- Corresponds with Phius



- Highly recommended
- Maintains quality and oversight throughout construction process



OR

- Required
- Early involvement recommended
- Site visits/inspections throughout construction
- Verifies compliance at final construction
- Corresponds with Phius

\*Rater - single family and small multifamily

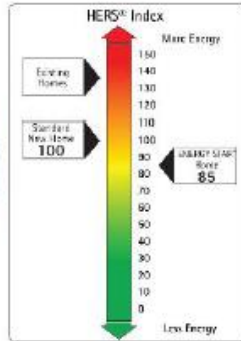
\*Verifier - non-residential and large multifamily





# US Department of Energy

## HIGH PERFORMANCE STAIRCASE



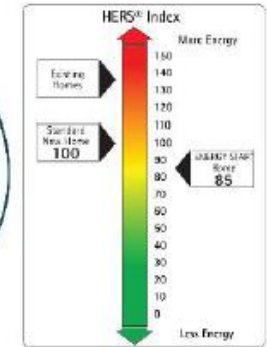
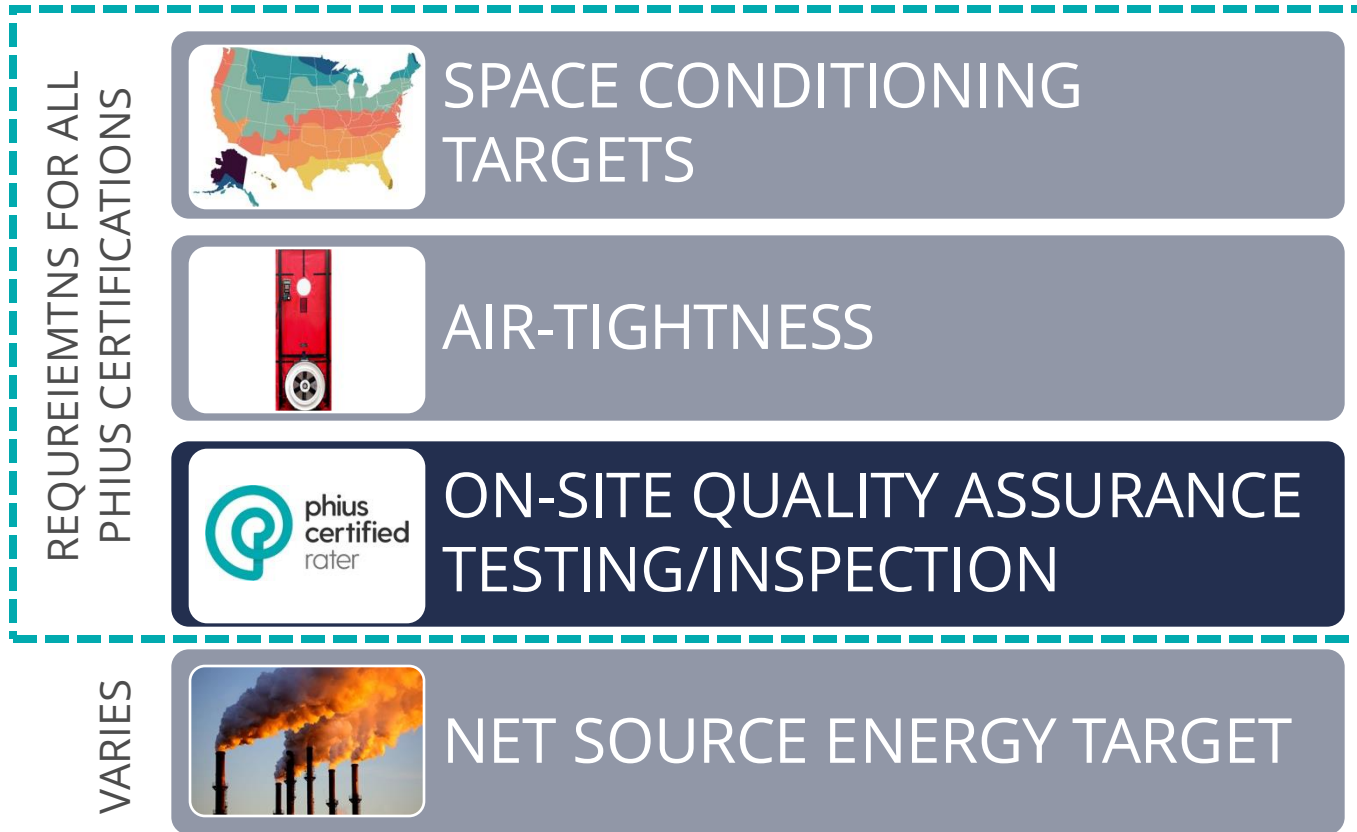
	HVAC QI w/WHV	HVAC QI w/WHV	HVAC QI w/WHV
	Water Management	Water Management	Water Management
	Independent HERS Verification	Independent HERS Verification	Independent HERS Verification
IECC 2012 Enclosure	IECC 2012 Enclosure	IECC 2012 Enclosure	IECC 2015/18 Encl./ES Win.
HERS 70-80	HERS 60-70	HERS 50-60	HERS 35-45
IECC 2012	ENERGY STAR v3	ENERGY STAR v3.1	ZERH

SOLAR READY Depends on climate
Eff. Comps. & H2O Distrib
EPA Indoor airPLUS VI
Ducts in Condit. Space

	Renewable Energy to Get to Zero
Electrification Readiness	No Fossil-Fuel Combustion On-Site
Electric Vehicle Readiness	Electric Vehicle Readiness
Balanced Ventilation HRV/ERV	Balanced Ventilation HRV/ERV
SOLAR READY ALWAYS	SOLAR READY ALWAYS
Eff. Comps. & H2O Distrib	Eff. Comps. & H2O Distrib
EPA Indoor airPLUS VI	EPA Indoor airPLUS VI
Ducts in Condit. Space	Ducts in Condit. Space
Micro-load HVAC QI	Micro-load HVAC QI
Water Management	Water Management
Independent HERS Verification	Independent HERS Verification
Ultra-Efficient Enclosure	Ultra-Efficient Enclosure
HERS 30-40	HERS < 0
phius CORE	phius ZERO

# QUALITY ASSURANCE / QUALITY CONTROL

## MAIN CERTIFICATION REQUIREMENTS



- ← **Based on:**
- Robust US systems
  - 3<sup>rd</sup> party inspection

# DISCUSSION POINTS

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**Bonus Point** – Beyond Net Zero

# The Future of America's Electric Grid

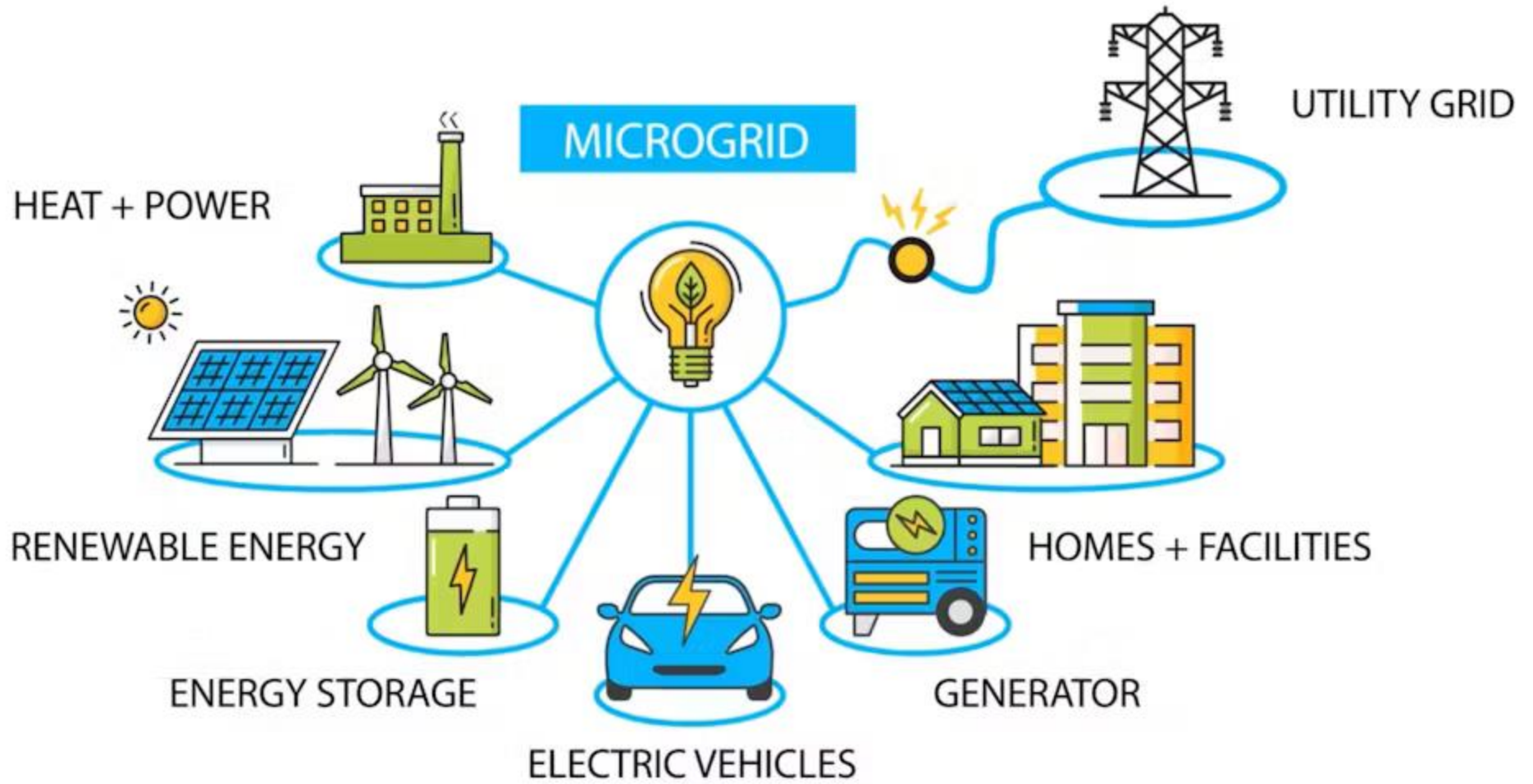
“You think of not only electric vehicles but also industry changing out natural gas for electricity for heating and manufacturing or data centers for artificial intelligence or cryptocurrency mining – these things require huge amounts of electricity that has never been needed before.” – Mark Petri

“At any moment, you could have new demands on the system... You need to be able to anticipate those demands and respond quickly so that you don't have cascading failure.” – Mark Petri

In a world in which the grid is supplied primarily by renewables with incorporated large-scale energy storage, it will have to be sensitive to the fact that there are certain times a day when the wind is not blowing, or the sun is not shining, and manage the demand appropriately.

“Maybe we need more batteries to back up the grid in that case, and we will need to accommodate new devices at the edge of the grid...but no matter what, it's going to certainly be a historic change to the way you would expect the grid to operate.” – Mark Petri

# Passive Designs Role



# What is Phius?



phius  
certified  
consultant



phius  
certified  
product

Calculation based on ISO 15017-2, EN 673, EN 410

Product name: ALPEN 725 High Performance Clearcoat

ASHRAE/IECC /DOE North American Climate Zone: North, East, West-facing / South, West-facing

Center of glass properties: Alpen HPF 725-T4 No Grids

Whole window installed U-value

Climate specific recommendations:	W/m <sup>2</sup> K	BTU/hr ft <sup>2</sup> F	SHGC	U-value	BTU/hr ft <sup>2</sup> F
6	1.02	0.18	0.558	0.703	0.124
7	1.00	0.18	0.558	0.678	0.119
8	1.00	0.18	0.558	0.664	0.116
9	1.00	0.18	0.558	0.686	0.121
10	1.01	0.18	0.558	0.692	0.122
11	1.01	0.18	0.558	0.695	0.123
12	1.02	0.18	0.558	0.702	0.124
13	1.01	0.18	0.558	0.698	0.123
14	1.03	0.18	0.558	0.716	0.126
15	1.03	0.18	0.558	0.716	0.126

ALPEN 725 High Performance

Aluminum 2509 SST	FRAME		U-frame		V		Phiglass	Phiglass
	Frame height	U-value	U-value	U-value	U-value	U-value		
Head	73	2.86	1.18	0.20	0.054	0.031	0.143	0.143
Sill	73	2.86	1.18	0.20	0.054	0.031	0.143	0.143
Left jamb	73	2.86	1.18	0.20	0.054	0.031	0.143	0.143
Right jamb	73	2.86	1.18	0.20	0.054	0.031	0.143	0.143

Valid through October 2018



phius  
ZERO



phius alliance  
CHICAGO



# The Phius Standard

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*is a **climate-specific passive building standard that prioritizes passive building principles and guides builders to success in the design and construction of high-performance buildings.***

*It provides a **quality-and-conservation-first framework for net zero building.***



**Thanks!**  
**Questions?**



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# Building a Better Future: A Regenerative Education Center

GREAT SMOKY  
MOUNTAINS  
INSTITUTE AT  
TREMONT



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# Introduction



**Catey McClary | President, CEO**

Great Smoky Mountain  
Institute at Tremont  
Townsend, TN

# Who is Tremont?

GREAT SMOKY MOUNTAINS INSTITUTE AT TREMONT

Tremont is a private, non-profit outdoor school located in Great Smoky Mountains National Park, where people of all ages come to **live and learn**. Our mission is to deliver experiential learning for youth, educators and adults through programs that promote self-discovery, critical thinking and effective teaching and leadership.



We achieve our mission through:



Residential programs



Research that complements our learning laboratory



Community engagement



Advocacy for outdoor learning



**In 2019, we set out to expand beyond the National Park boundary and purchased 200 acres to build a second campus.**

We decided early on that we wanted our campus to embody our mission: a place where people connected to nature and to each other, and a place with programs that promote a greater wellbeing for people AND their environment.

And then I learned about the LBC, which asks:

**“Imagine a building as connected as a forest ecosystem.”**



## WE ARE LIVING AND LEARNING IN THE FOREST

For us, the question was how to replicate the connection to nature and the wellness benefits we experience in 50-year-old facilities and recreate this in our new campus. The Living Building Challenge was our answer.

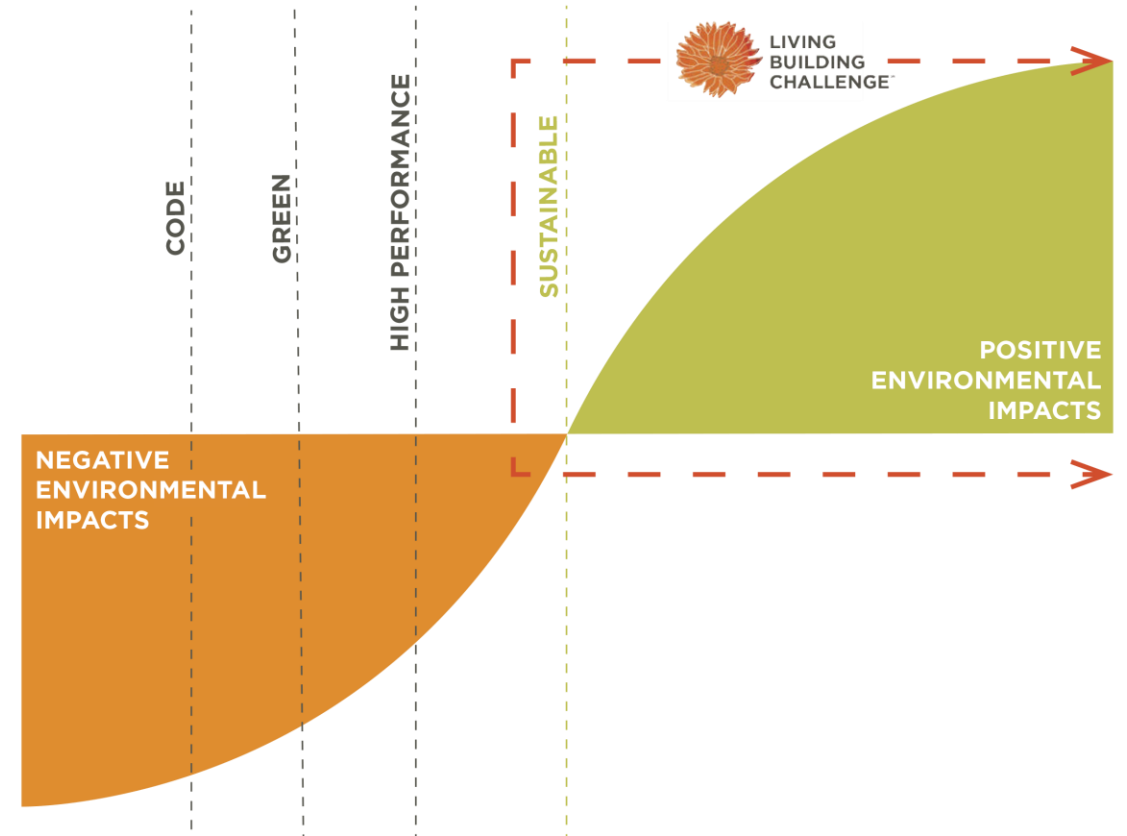
**We don't have to imagine a  
forest ecosystem...**



# A Paradigm Shift

What if every single act of design and construction made the world a better place?

[www.living-future.org](http://www.living-future.org)





**BEAUTY**



**WATER**



**MATERIALS**



**PLACE**



**ENERGY**



**EQUITY**



**HEALTH +  
HAPPINESS**

# Embracing the Living Building Challenge

We've come to see LBC as the embodiment of our mission, so for us, this isn't just about buildings, but the relationship of people, the built environment and the natural environment. How does this intersection inspire connection and stewardship?



**We're following nature's example.**





# Fostering Community Change through Partnerships



Through collaborative efforts with local partners, forward-thinking architects and industry innovators, we're not just constructing a physical space – we're constructing a sustainable future.





Gathering Building Entry



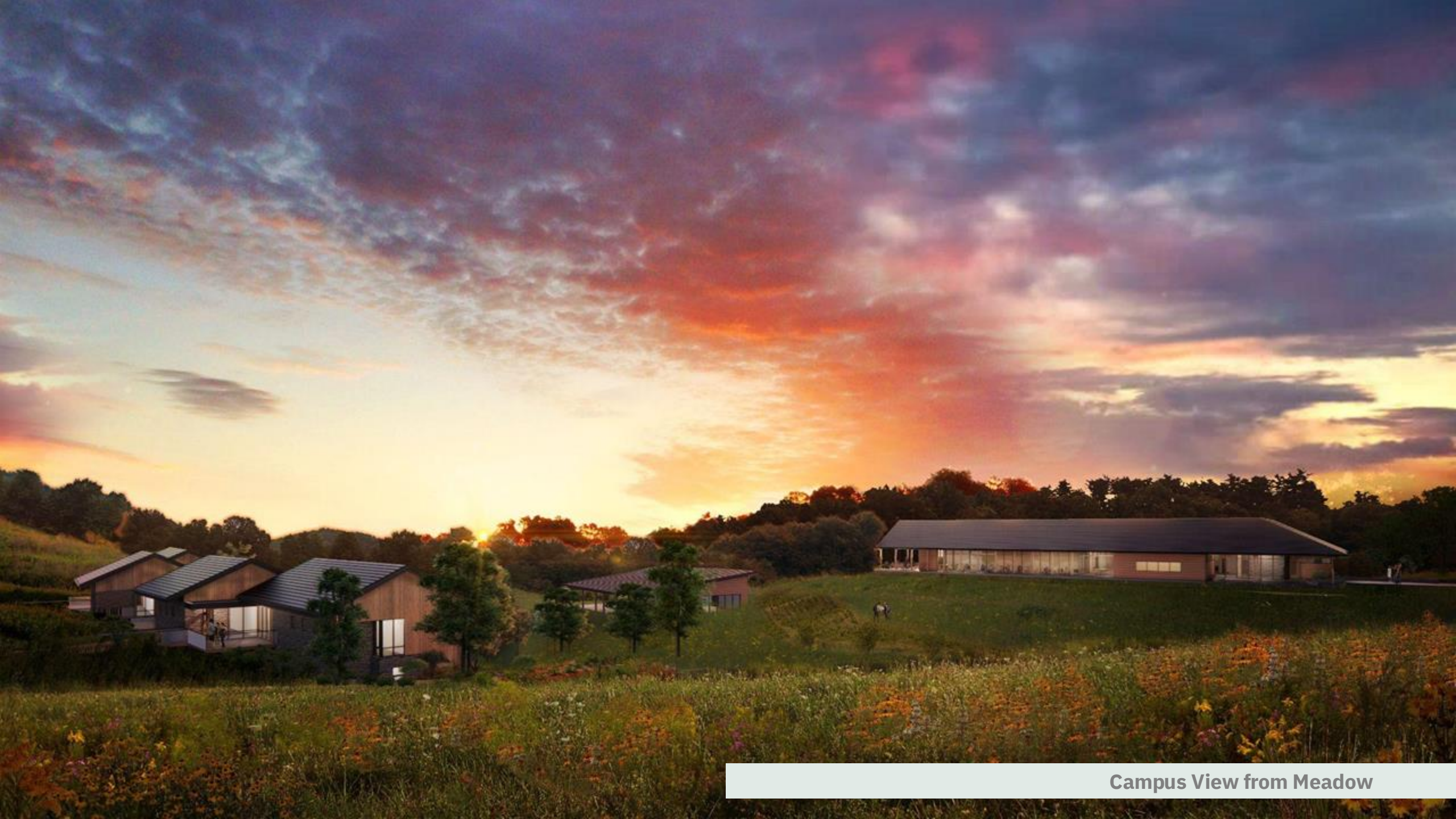
Gathering Building Dining / Multi-Purpose Space



Dorms from Gathering Building Patio



Staff Housing Renovation and Addition



Campus View from Meadow

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# Thank you!



**Catey McClary** | President, CEO

Great Smoky Mountain Institute at Tremont

Townsend, TN

[catey@gsmiit.org](mailto:catey@gsmiit.org)



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# Panel Discussion



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# Let's Stay Connected



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## Continue the Conversation

Contact Georgia Caruthers to learn more:

[gmcaruthers@tva.gov](mailto:gmcaruthers@tva.gov)

Or

[ConnectedCommunities@tva.gov](mailto:ConnectedCommunities@tva.gov)



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## Join Our Connected Communities Network

Visit the Connected Communities website and sign up to be part of the Connected Communities Network:

[tva.com/connectedcommunities](http://tva.com/connectedcommunities)



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## Access Our Resources

Access the Community Information Hub and relevant guides:

[Community Information Hub](#)

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