The Sponsors of Energize Connecticut, and in partnership with Connecticut Passive House, are pleased to offer *Passive House & All-Electric Homes Initiative* to support workforce development and help transform the energy efficiency and building construction industries in Connecticut.

For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com
Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more
# Passive House Incentive Structure for Multi-Family (5 Units or More)

<table>
<thead>
<tr>
<th>Incentive Timing</th>
<th>Activity</th>
<th>Incentive Amount</th>
<th>Max Incentive (Per Unit)</th>
<th>Max Incentive (Per Project)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Construction</td>
<td>Feasibility Study&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Up to 100% of Feasibility Study Costs</td>
<td>N/A</td>
<td>$5,000.00</td>
</tr>
<tr>
<td></td>
<td>Energy Modeling&lt;sup&gt;2&lt;/sup&gt;</td>
<td>75% of Energy Modeling Costs (Before 90% Design Drawings)</td>
<td>$500.00</td>
<td>$30,000.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% of Energy Modeling Costs (90% Design/50% Construction)</td>
<td>$250.00</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Post Construction</td>
<td>Certification&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Up to 100% of Certification Costs</td>
<td>$1,500.00</td>
<td>$60,000.00</td>
</tr>
</tbody>
</table>

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant.
2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.
3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.

Next steps you can take...
Contact your Energy Efficiency Representative or

Go to [EnergizeCT.com](https://www.energizect.com) or call 1-877-WISE USE for more details.

Brought to you by

[![Eversource](https://example.com/eversource.png)](https://example.com/eversource)

Part of the AVANGRID Family

Proud sponsors of

[![Energize Connecticut](https://example.com/energize-connecticut.png)](https://example.com/energize-connecticut)
The future of high-performance, all-electric homes starts here.
## Level 1

<table>
<thead>
<tr>
<th>Feature</th>
<th>Single Family (Detached Dwellings)</th>
<th>Multifamily (Attached Dwellings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total UA Alternative Compliance or HERS Index Score</td>
<td>Total UA &gt; 7.5% better than 2021 IECC or HERS Index Score ≤ 55</td>
<td>Total UA &gt; 15% better than 2021 IECC or HERS Index Score ≤ 45</td>
</tr>
<tr>
<td>Heat pump for space heating **</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Space Conditioning Connectivity &amp; Controls ***</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Heat pump for water heating</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Hot Water Distribution ******</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Envelope Infiltration Rate (ACH)</td>
<td>ACH50 ≤ 2.5</td>
<td>CFA &gt; 850h2: ACH50 &lt; 4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFA &lt; 850h2: ACH50 ≤ 5.0</td>
</tr>
<tr>
<td>Duct Leakage Rate (CFM)</td>
<td>2021 IECC code minimum requirements</td>
<td>All ductwork must be located in conditioned space</td>
</tr>
<tr>
<td>Balanced Ventilation Systems</td>
<td>Optional</td>
<td>Required</td>
</tr>
<tr>
<td>Induction Cooking</td>
<td>Optional</td>
<td>Required</td>
</tr>
<tr>
<td>Electric Vehicle Readiness *******</td>
<td>Required</td>
<td>Optional</td>
</tr>
</tbody>
</table>

## Level 2

<table>
<thead>
<tr>
<th>Feature</th>
<th>Single Family (Detached Dwellings)</th>
<th>Multifamily (Attached Dwellings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFA &gt; 850h2: ACH50 ≤ 4.0</td>
<td>CFA &gt; 850h2: ACH50 &lt; 3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CFA &lt; 850h2: ACH50 ≤ 4.0</td>
<td></td>
</tr>
</tbody>
</table>

### All-Electric Home Incentive Structure

<table>
<thead>
<tr>
<th>Level</th>
<th>Single Family</th>
<th>Single Family Attached</th>
<th>Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>$7,500</td>
<td>$2,000</td>
<td>$1,500</td>
</tr>
<tr>
<td>Level 2</td>
<td>$10,000</td>
<td>$5,000</td>
<td>$2,500</td>
</tr>
</tbody>
</table>

Next steps you can take...
Contact your Energy Efficiency Representative or

Go to EnergizeCT.com or call 1-877-WISE USE for more details.

Brought to you by Eversource
Proud Sponsors of CNG, SCG, UI
Part of the AVANGRID Family
Thank You

For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com
TIMBER + HP = High Performance
Healthy Planet
Healthy People

Building envelope, thermal, and acoustic solutions
A comprehensive, above-grade product line to create wind-tight, vapor-open assemblies offering stable, long-term R-values, improved temperature stability, and premium sound protection

Recyclable, renewable, non-toxic, and carbon negative
Made from residual wood chips to maximize the use of our renewable forest resource. As a high-value insulator with a negative carbon footprint, reduces a building’s global warming potential on day one and everyday it operates

Moisture managing, safe, and sound absorbing
Installers benefit from the absence of dangerous fibers that harm skin and negatively impact air quality. Leads to the creation of safe, quiet indoor habitats, free of airborne toxins and trapped humidity
Introducing TimberHP
Wood Fiber Insulation made in America

- **Carbon Storing**
  The only insulation on the market to do this

- **High Performance**
  Manages air, moisture, conductivity, and sound

- **Highly Recyclable**
  When you cut it, you get sawdust

- **Nontoxic, Safe**
  Leading to healthy indoor air quality

- **Class A/B Flame Spread**
  Offers a high degree of fire protection
TIMBER HP
Thermal and Acoustic Solutions for Above-Grade Applications

Wood Fiber Insulation
Made in America
Coming 2023

TimberFill
Production Begins Q2
Certified Product Available Q3

TimberBatt
Production Begins Q3
Certified Product Available Q4

TimberBoard
Production Begins Q4
Certified Product Available Q1, 2024

INSULATE BETTER. LIVE BETTER.™
Solving Performance Demands Using Wood Fiber Insulation

Scott Johnston, CSI & CDT
TimberHP Senior Northeast Business Development Manager
Scott.Johnston@timberhp.com

Paige Molly
TimberHP Territory Sales Manager
Paige.Molly@timberhp.com
TimberHP is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.
Learning Objectives

**Learning Objective 1:** Working knowledge of insulation products available on the market today and the impact of new building codes on the building envelope. Convey why now more than ever selecting the right insulation has a greater impact on our environment than ever before.

**Learning Objective 2:** Understanding of wood fiber insulation which includes a knowledge of positive sustainability implications; fire, bugs, and water; and why wood fiber stands up to these field liabilities and performs to code.

**Learning Objective 3:** Ability to explain the importance of code compliance and how climate zone impacts assembly design. Ability to understand thermal bridging and how to address the condition, especially in cold climate regions.

**Learning Objective 4:** Knowledge of Life Cycle Analysis modeling and how it is used to help better understand building materials impact on the environment. A strong understanding of Embodied Carbon Emissions and how product selection moving forward can help reduce its impact on the environment.
Course Outline

PART 1
Current Insulation Market

PART 2
What is Wood Fiber Insulation

PART 3
Code Compliance

PART 4
Embodied Carbon and Wood Fiber Insulation
AIA Credit Awarding: Solving Performance Demands Using Wood Fiber Insulation

WEBINAR CREDIT INQUIRIES:
alexandra.hodges@timberhp.com
OR
info@timberhp.com
PART ONE
Current Insulation Market
Current Insulation Market

Increases to the minimum R-value (thermal value) within the mainstream US energy code—International Energy Conservation Code (IECC)—since 2006 have increased demand for insulation and driven new renovations.

Source: PR Newswire, MarketWatch, AIA 2030, Graphic from IECC
Reducing Thermal Bridging With Continuous Insulation – Today’s Solutions

Framing accounts for 20 – 25% of exterior wall
While modern regulations are driving demand, insulation solutions in the US are outdated.
In the US, Fiberglass & Foam dominate the market with over 90% of market share.

Source: AIA 2030, IAL Consultants, Gupta-Verlag
Current insulation options are costly, unsafe, or unsustainable:

<table>
<thead>
<tr>
<th>FIBERGLASS</th>
<th>FOAMED PLASTICS</th>
<th>MINERAL WOOL</th>
<th>CELLULOSE</th>
<th>COTTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1938</td>
<td>1950s</td>
<td>1953</td>
<td>1950s</td>
<td>1970s</td>
</tr>
<tr>
<td>Glass</td>
<td>Oil-derived chemicals</td>
<td>Rock</td>
<td>Shredded paper products</td>
<td>Recycled denim</td>
</tr>
</tbody>
</table>

Though most are now formaldehyde-free they can still **off gas** due to binders. Commodity fiberglass allows for cavity **wind washing** and doesn’t rebound at install.

If applied improperly can **cause fires** or hold in damaging **leaks and humidity**. Requires protective gear for **toxic** off-gassing. Cannot be removed without **damage**.

Is flame-retardant but an **extreme irritant** when handled with bare skin. Can be **hazardous**, difficult to cut, and is not easily disposable. High **embodied carbon** and still uses **formaldehyde**.

Is falling victim to **shrinking feedstock**, resulting in more plastics. Powdered flame retardant can make install dusty and lead to long-term **performance issues**.

Has very little feedstock and is quite **costly** to produce. Requires application of **powdered flame retardant**.

Source: MarketWatch, AIA 2030, Focus Groups with all three audience groups conducted in Boston, MA & Seattle, WA by Schireson Associates & Blackbird Global (March 2019).
PART TWO

Introducing Wood Fiber Insulation
Introducing Wood Fiber Insulation

- **Carbon Storing**: The only scalable carbon-negative insulation on the market
- **High Performance**: Manages air, moisture, conductivity, and sound
- **Highly Recyclable**: When you cut it, you get sawdust
- **Nontoxic, Safe**: Leading to healthy indoor air quality
- **Class A/B Flame Spread**: Offers a high degree of fire protection
European wood fiber insulation market shows product potential in North America

- 15 manufacturing facilities in Europe with 5 more under construction
- Estimated $800 m (~5% of total insulation market) for all three products (board, batt and loose fill)
- Freedonia forecast the European market will reach $1 b in demand by the end of 2023
- Product is sold at a 20% premium in a market that is only 25% wood frame construction

Freight costs combined with high production costs limit the sale of European wood fiber insulation in North America to select projects only where price is not a factor.
EUROPEAN SUPPLIERS OF WOOD FIBER INSULATION

STEICO
engineered by nature

best wood®

GUTEX®
naturally made from wood

Pavatex

BELTERMO®

AGEPAN® SYSTEM

Beton Wood

HUNTON
By nature. For nature.

INOTHERMO
Meine natürliche Dämmung!

UNGER DIFFUTHERM®
Environmentally-friendly, innovative, insulation systems

Freight and high production costs limit the sale of European wood fiber insulation in North America.
Utilizing an Abundant Waste Resource

Made from clean, species-agnostic, softwood residuals; insulating wood fiber composites are a perfect fit for the US wood products manufacturing sector.
Maine Makes the Difference

Since 2014, Maine alone has lost markets for over 4 million tons of low-grade wood that would have otherwise supplied paper and biomass mills.

Wood fiber insulation production is able to provide a new market for those chips, supporting foresters and loggers throughout Maine and beyond.
With the decline in paper production, the robust wood baskets of the US and Canada need new manufacturers who create high-demand products from sawmill residuals and low-value fiber.

Domestically Produced Wood Fiber Insulation: Price Comparison*

*Within Madison Target Market
Market Position

Drop-In Replacement

- Affordable, low-risk replacement for foam, mineral wool, cellulose, fiberglass, and other traditional insulating products for above-grade assemblies
- Meet thermal and acoustic demands with the same product offering

Comprehensive Above-Grade System

- Full-line of insulating products made from one material to address cavity, continuous, and attic blanket applications
- Prescriptive building envelope approach to create wind-tight, vapor-open assemblies
Market Fit

• Code-compliant building envelope, thermal, and acoustic assemblies for residential new construction and remodeling
  • Single-family and multi-family

• Commercial and institutional
  • Buildings 4 stories or less
  • Mass timber and cross laminated timber

• Factory-built solutions
  • Residential and commercial prefab
  • Panel, full-scale, modular designs

• Passive House, net zero, carbon negative, bio-based
Loose Fill and Dense Pack Insulation

APPLICATIONS
- Dense pack cavity insulation in stud walls and between rafters and joists
- Loose fill blanket insulation for attics

COMPOSITION
- Softwood fiber fire treated with boric acid

PRODUCT MERITS
- R-3.8/inch
- Achieve desired R-value with less volume compared to other blown-in options
- Shape and size of fibers prevent issues with settling, reducing voids and air pockets
- Boric acid full fiber penetration—Class A Flame Spread, mold/mildew and pest inhibitor
- Pure, consistent feedstock. Low dust, no toxins, free of printing ink, no foreign contaminants

Borate is more than a fire retardant; it inhibits mold and mildew growth and prevents pests.
Batt Insulation

APPLICATIONS
- Thermal cavity insulation
- Acoustic insulation for interior spaces and demising walls

COMPOSITION
- Softwood fiber, polyamide binding fiber, boric acid

SIZING
- Wood and non-structural steel framing
- 16” and 24” OC
- 3”; 3.5”; 5.5”; 6”; 7.25”

DISTINCTIVE PRODUCT MERITS
- R-4/inch, vapor open
- Flexible, semi-rigid. Most durable batt on the market
- No toxins and no harmful fibers
- Boric acid full fiber penetration—Class A Flame Spread, mold/mildew and pest inhibitor
- Low thermal conductivity and high heat capacity

R - 4 / inch
Continuous Board Insulation

APPLICATIONS
- Exterior continuous insulation
- Interior insulation of walls, floors, and ceilings

COMPOSITION
- Softwood fiber, PMDI Adhesive, and Paraffin

SIZING
- Thickness 1”-9.25” Width 2’ & 4’ Length 4’ & 8’

DISTINCTIVE PRODUCT MERITS
- Stable R-3.4 to 3.7/inch
- Hydrophobic and vapor open for superior performance
- High compressive strength (10 – 20 psi)
- Class B Flame Spread with no fire retardants
- Buffers changes in humidity and temperature

R–3.4– 3.7 / inch
College of the Atlantic

Bulk moisture demonstration
Wood Fiber Manages Moisture

Wood fiber insulation offers high vapor permeability (40 to 70 perms/inch) allowing for drying to both the inside and outside of buildings.

Wood fiber can hold 15% of its weight in moisture without losing insulating properties.

Through capillary action, moisture is spread out across the insulation and dries either to the inside or outside of the building depending on temperature, pressure, and humidity levels.

- High structural resilience by reducing chance of rot
- More comfortable indoor humidity levels
- Healthier indoor air quality

Breathable insulation results in healthy indoor air quality.
Low Thermal Conductivity & High Heat Capacity balance temperature swings in conditioned spaces, reducing heating and cooling loads.

Wood fiber absorbs heat slowly over time and radiates warmth out when cooler conditions exist:

• Guards against summer heat
• Saves the heat we buy in the winter
Unmatched Heat Protection

Resulting from product density and the combined high heat capacity and low thermal conductivity of wood, wood fiber insulation delays heat transfer and increases temperature stability in our buildings.

Beyond R-VALUE

Temperature Rise Comparison

Heat Lamp Applied

MineralFiber

XPS

TimberBoard

Time in Minutes

R-5
per inch

R-3.6
per inch

R-4
per inch

XPS FOAM BOARD

WOOD FIBER

MINERAL WOOL

THERMAL DIFFUSIVITY DEMONSTRATION
Opening the indoors
Vapor-open assemblies allow structures to breathe and indoor humidity to escape

No trapped moisture means less chance for mold and mildew, less chance for respiratory issues and allergies

Acoustics
Best-in-class acoustics and pure fiber are the building blocks for the new indoor habitat
Wood fiber batt steel frame wall
Acoustic Performance

Wood fiber provides a compelling option.

Mineral Wool Batt

---

**Acoustics**

**Assembly Number**: ISS-08

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Finish material</strong></td>
<td>5/8&quot; gypsum</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>3 5/8&quot; Steel Stud</td>
</tr>
<tr>
<td><strong>Spacing</strong></td>
<td>16&quot; oc</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>3.5&quot;</td>
</tr>
<tr>
<td><strong>Resilient Channels</strong></td>
<td>RC Deluxe, 16&quot; OC</td>
</tr>
</tbody>
</table>

**Transmission Loss (dB)**

- **STC**: 45
- **OITC**: 29
- **Report No.**: NWTL140829-01

---

**SOUND TRANSMISSION RESULTS**

*Graph showing sound transmission loss vs. frequency*
Wood fiber batt / wood frame wall Acoustic Performance

This same wall in a 2x4 profile achieved a sound transmission class (STC) of 50 vs. mineral wool at 47.

Both batt and fill @5.5” noise reduction coefficient (NRC) 1.15 (sound absorption)
Healthy People

Just Wood

Over 90% of every insulating product is softwood residuals

No toxins to breathe
No fibers to irritate skin

When you cut wood fiber insulation, you produce sawdust.

It can be handled and installed without wearing gloves, long sleeves, or chemical respirators. Installers appreciate insulation free of toxins and abrasives.
PART THREE

Code Allowed Applications for Wood Fiber Insulation

NATIONAL FIRE PROTECTION ASSOCIATION CODES,
INTERNATIONAL BUILDING CODE,
INTERNATIONAL ENERGY CONSERVATION CODE
US and Canada Code Compliance

ASTM C739 CAN/ULC-S703 - Standard Specification for Cellulosic Fiber
ASTM 119/E84 CAN/ULC S102

ASTM C739 CAN/ULC-S703 - (Abridged) Standard Specification for Cellulosic Fiber
ASTM 119/E84 CAN/ULC S102

ASTM (abridged) C208/209 Standard for Cellulosic Fiber Insulating Board
ASTM 119/E84 CAN/ULC S102

Additional fire assembly testing UL listings (ASTM E119/UL 263)
Hygrothermal analysis code compliance and best practices
Sound testing (assemblies)
Evaluation Services Reports
NFPA 285 Definitions for Material Combustibility

- **Combustible Material**: will ignite and burn in the form in which it is used and under the conditions anticipated
  - Wood Framing, OSB
  - Cellulose, Foam, Wood Fiber Insulation
- **Non-Combustible Material**: will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat in the form in which it is used and under the conditions anticipated (Passes ASTM E 136 at 750C)
  - Brick/Concrete/Cement
  - Mineral Wool Insulation
IBC Construction Types Where Wood Fiber is Allowed

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Combustible Structure</td>
<td>Non-Combustible Structure</td>
<td>Non-Combustible Exterior Walls/Combustible Interior Structural Frames</td>
<td>Non-Combustible Exterior Walls/Combustible Interior Structural Frames</td>
<td>Combustible Construction</td>
</tr>
</tbody>
</table>

- Each type has an “A” and a “B” sub-category, “A” has increased fire protection requirements
### IBC Construction Types Where Wood Fiber is Allowed

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Combustible</td>
<td>Non-Combustible</td>
<td>Non-Combustible Exterior Walls/</td>
<td>Non-Combustible Exterior Walls/</td>
<td>Combustible Construction</td>
</tr>
<tr>
<td>Structure</td>
<td>Structure</td>
<td>Combustible Interior Structural Frames</td>
<td>Combustible Interior Structural Frames</td>
<td></td>
</tr>
</tbody>
</table>

- Each type has an “A” and a “B” sub-category, “A” has increased fire protection requirements
### IBC Maximum Building Height

<table>
<thead>
<tr>
<th>Building Use</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly *</td>
<td>Unlimited</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Education</td>
<td>Unlimited</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>Unlimited</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Factory</td>
<td>Unlimited</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>High Hazard</td>
<td>Unlimited</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Institutional</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Mercantile</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Residential</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Storage</td>
<td>Unlimited</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Utility</td>
<td>Unlimited</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

* Where a building is equipped with an approved automatic sprinkler system, the maximum number of stories is increased by one
**IBC Maximum Building Height**

<table>
<thead>
<tr>
<th>Building Use</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly *</td>
<td>Unlimited</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Education</td>
<td>Unlimited</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>Unlimited</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Factory</td>
<td>Unlimited</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>High Hazard</td>
<td>Unlimited</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Institutional</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Mercantile</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Residential</td>
<td>Unlimited</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Storage</td>
<td>Unlimited</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Utility</td>
<td>Unlimited</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

* Where a building is equipped with an approved automatic sprinkler system, the maximum number of stories is increased by one.
Building Code Drives Tighter Buildings and Higher R-Values

- Not just more insulation, but continuous insulation
- Climate zone and basic requirements
- More insulation can mean more problems
- View the building envelope as a system
IECC 2018 Minimum Insulation Requirements

<table>
<thead>
<tr>
<th>WALL</th>
<th>METAL FRAMED</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 EXCEPT MARINE</th>
<th>5 &amp; MARINE 4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-13 + 5 c.i.</td>
<td>R-13 + 7.5 c.i.</td>
<td>R-13 + 7.5 c.i.</td>
<td>R-13 + 7.5 c.i.</td>
<td>R-13 + 7.5 c.i.</td>
<td>R-13 + 7.5 c.i.</td>
<td>R-13 + 15.6 c.i.</td>
<td>R-13 + 17.5 c.i.</td>
<td></td>
</tr>
<tr>
<td>WOOD FRAMED</td>
<td>R-20</td>
<td>R-20</td>
<td>R-20</td>
<td>R-20</td>
<td>R-20 + 3.8 c.i.</td>
<td>R-20 + 3.8 c.i.</td>
<td>R-20 + 3.8 c.i.</td>
<td>R-20 + 10 c.i.</td>
<td></td>
</tr>
</tbody>
</table>

NR = Not Required; c.i. = continuous insulation
**Tighter Buildings Can Bring More Risk**

**TABLE N1102.1.3 (R402.1.3)**  
INSULATION REQUIREMENTS BY COMPONENT

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Wood Framed Wall (R-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13 or 0+10</td>
</tr>
<tr>
<td>2</td>
<td>13 or 0+10</td>
</tr>
<tr>
<td>3</td>
<td>20 or 13+5h or 0+15</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>30 or 20+5h or 13+10h or 0+15h</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>30 or 20+5h or 13+10h or 0+15h</td>
</tr>
<tr>
<td>6</td>
<td>30 or 20+5h or 13+10h or 0+20h</td>
</tr>
<tr>
<td>7&amp;8</td>
<td>30 or 20+5h or 13+10h or 0+20h</td>
</tr>
</tbody>
</table>

---

**Blower Door Testing**  
Leakage = Air Changes per Hour (ACH)

- **Testing R402.4.2.1**  
  - Optional  
  - Approved 3rd Party  
  - Written Report

- **Testing R402.4.1.2**  
  - MANDATORY  
  - Approved 3rd Party  
  - Written Report

**Calculation**  
ACH50 (Air Change per Hour at 50 Pascals)  
\[ \frac{\text{CFM50 x 60}}{\text{VOLUME}} = \text{ACH50} \]  
7 ACH50 or Less  
Not Exceeding 3 ACH50

---

a. R-values are minimums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.

h. The first value is cavity insulation, the second value is continuous insulation, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation.
Houses don’t need to breathe... people do.
# IBC 2018 Vapor Retarder Mandatory Requirements

<table>
<thead>
<tr>
<th>Vapor Retarder</th>
<th>1 &amp; 2</th>
<th>3 &amp; 4 Except Marine</th>
<th>Marine 4</th>
<th>5</th>
<th>6</th>
<th>7 &amp; 8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class I</strong></td>
<td>☒</td>
<td>☒</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td><strong>Class II</strong></td>
<td>☒</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td><strong>Class III</strong></td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>

*Only Class III is allowed on the interior side of frame wall if foam insulating sheathing with a perm rating of less than 1 is applied on the exterior side of frame wall.*

- Vented cladding over wood structural panels, fiberboard or gypsum, or
- Continuous insulation with R≥2.5 (2x4 wall) or R≥3.75 (2x6 wall)
- Vented cladding over wood structural panels, fiberboard or gypsum, or
- Continuous insulation with R≥5 (2x4 wall) or R≥7.5 (2x6 wall)
- Vented cladding over fiberboard or gypsum, or
- Continuous insulation with R≥7.5 (2x4 wall) or R≥11.25 (2x6 wall)
- Continuous insulation with R≥10 (2x4 wall) or R≥15 (2x6 wall)
IBC 2018 Vapor Retarder Mandatory Requirements

**CLASS I** \( \leq 0.1 \text{ Perm} \)

**CLASS II** \( 0.1 \text{ Perm} < \leq 1 \text{ Perm} \)

**CLASS III** \( 1 \text{ Perm} < \leq 10 \text{ Perm} \)

**Vapor Permeable** \( 10 \text{ Perm} < \)**

- Vapor Retarder class shall be based on the manufacturer’s certified testing or a tested assembly

<table>
<thead>
<tr>
<th>Class</th>
<th>Common Vapor Retarders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Sheet polyethylene</td>
</tr>
<tr>
<td></td>
<td>Nonperforated aluminum foil</td>
</tr>
<tr>
<td>Class II</td>
<td>( \geq 1'' ) XPS</td>
</tr>
<tr>
<td></td>
<td>Kraft-faced fiberglass batt</td>
</tr>
<tr>
<td>Class III</td>
<td>( \frac{3}{8}'' ) Plywood (exterior glue)</td>
</tr>
<tr>
<td></td>
<td>Latex or enamel paint</td>
</tr>
<tr>
<td></td>
<td>OSB sheathing</td>
</tr>
<tr>
<td>Vapor Permeable</td>
<td>Wood Fiber Insulation</td>
</tr>
<tr>
<td></td>
<td>Mineral Wool</td>
</tr>
</tbody>
</table>
### TABLE R702.7.1
CLASS III VAPOR RETARDERS : LATEX OR ENAMEL PAINT

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>CLASS III VAPOR RETARDERS PERMITTED FOR:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine 4</td>
<td>- Cl with R-value ≥ 2.5 over a 2x4 wall</td>
</tr>
<tr>
<td></td>
<td>- Cl with R-value ≥ 3.75 over a 2x6 wall</td>
</tr>
<tr>
<td>5</td>
<td>- Cl with R-value ≥ 5 over a 2x4 wall</td>
</tr>
<tr>
<td></td>
<td>- Cl with R-value ≥ 7.5 over a 2x6 wall</td>
</tr>
<tr>
<td>6</td>
<td>- Cl with R-value ≥ 7.5 over a 2x4 wall</td>
</tr>
<tr>
<td></td>
<td>- Cl with R-value ≥ 11.25 over a 2x6 wall</td>
</tr>
<tr>
<td>7</td>
<td>- Cl with R-value ≥ 10 over a 2x4 wall</td>
</tr>
<tr>
<td></td>
<td>- Cl with R-value ≥ 15 over a 2x6 wall</td>
</tr>
<tr>
<td>8</td>
<td>- Cl with R-value ≥ 12.5 over a 2x4 wall</td>
</tr>
<tr>
<td></td>
<td>- Cl with R-value ≥ 20 over a 2x6 wall</td>
</tr>
</tbody>
</table>

a. Cl = Continuous Insulation

b. The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class III vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of Chapter 11.
Reduce Risk with Flow-Through Assemblies

- **Vapor Open**: So no moisture is trapped
- **Resilient Performance**: Lasting for generations
- **Hydrophobic**: Repelling precipitation during construction
- **Capillary Action**: Moves and releases moisture through
PART FOUR

Embodied Carbon and Wood Fiber Insulation
Embodied Carbon - Life Cycle Analysis
Built Environment and Energy Consumption
(CO$_2$e emissions in 2017)

The construction and operation of buildings in the United States alone is responsible for almost 2 Gigatons CO$_2$e emissions annually.

The prescription for dramatically reducing that impact is well understood and immediately technologically achievable.

Embodied Carbon from Building Materials is responsible for 8.2% of global GHG emissions

- **Embodied Carbon** is the amount of greenhouse gases emitted during the life cycle of a material
- **Life Cycle Analysis (LCA)** is a tool that quantifies a product’s carbon footprint through a holistic view of its environmental interactions from cradle to grave
  1. Extraction and transportation of raw materials
  2. Manufacture of product
  3. Use of product
  4. End-of-life treatment (disposal or recycle)

Embodied Carbon is increasingly significant

By 2050, it is projected that embodied carbon will take up almost half the total carbon emissions from new construction.

Energy Retrofit Programs

Renewable Energy

Reduced Operational CO$_2$e
Problem: The insulation market is dominated by fossil-fuel dependent products with devastating environmental impacts

- **High Embodied Carbon**
  Irredeemable Global Warming Potential

- **Vapor closed, traps moisture**
  Leading to mold and mildew, health risks, and rot

- **Non-recyclable, made with toxins**
  Loaded with dangerous toxic ingredients

- **Harmful off-gassing**
  Leading to unhealthy indoor air quality

- **Highly flammable**
Atmospheric carbon dioxide is taken up by trees and, through photosynthesis, stored as carbon in biomass. At the end of the tree’s life, when left to decay, this stored carbon returns to the atmosphere slowly. Harvesting trees as the source material for building products can delay the release of that carbon for the life of the building and potentially far longer.

Solution: Wood Fiber Insulation

Carbon storing wood products used in construction yield a net benefit to the atmosphere.
Carbon Footprint

- WOOD FIBER: 2 kg CO₂
  Per 100SF @ R=1

- FIBERGLASS: 14 kg CO₂
  Per 100SF @ R=1

- MINERAL WOOL: 15 kg CO₂
  Per 100SF @ R=1

- SPRAY FOAM: 36 kg CO₂
  Per 100SF @ R=1

- XPS: -9 kg CO₂
  Per 100SF @ R=1
Embodied CO₂
1,500 SF Passive House Wall Assembly
Embodied CO₂
1,500 SF Passive House Wall Assembly

2x6 Batt Insulation

- **Fiberglass**: 1,450 lbs CO₂
- **Mineral Wool**: 2,500 lbs CO₂
- **Wood Fiber**: -3,100 lbs CO₂

Total CO₂: 5,600 lbs CO₂
The CO₂ savings for one house is equivalent to the emissions from driving 7,100 miles.

2x6 Batt Insulation

- Fiberglass: 1,450 lbs CO₂
- Mineral Wool: 2,500 lbs CO₂

Embodied CO₂
1,500 SF Passive House Wall Assembly
Embodied CO₂
1,500 SF Passive House Wall Assembly

2x6 Batt Insulation

- Fiberglass: -8,600 lbs CO₂
- Mineral Wool: 5,600 lbs CO₂
- Wood Fiber: -8,600 lbs CO₂

5.5” Board Insulation

- EPS: 4,500 lbs CO₂
- Mineral Wool: 10,550 lbs CO₂

Embodied CO₂ 1,500 SF Passive House Wall Assembly
Embodied CO\(_2\)

1,500 SF Passive House Wall Assembly

The CO\(_2\) savings for one house is equivalent to the emissions from driving 23,500 miles.

### Embodied CO\(_2\) Savings

- **Wood Fiber**: -8,600 lbs CO\(_2\)
- **EPS**: 4,500 lbs CO\(_2\)
- **Mineral Wool**: 10,550 lbs CO\(_2\)
- **5.5” Board Insulation**: 19,150 lbs CO\(_2\)

### 2x6 Batt Insulation

- **Fiberglass**: 5,600 lbs CO\(_2\)
- **Mineral Wool**: 11,500 lbs CO\(_2\)
The total CO$_2$ savings for one house is equivalent to the emissions from driving 1 car for 2.5 years

Total CO$_{2e}$ saved over mineral wool: 24,750 lbs CO$_2$
The greatest opportunity for reducing embodied carbon after concrete is *insulation*.

- **Concrete**: 14%-33% reduction, None to low-cost premium
- **Insulation**: 16% reduction, *No cost premium*
- **Rebar**: 4%-10% reduction, None to low-cost premium
- **Finish Materials**: 5% reduction, None to low-cost premium
- **Glazing**: 3% reduction, 10% cost premium

*Data Source: RMI*