Beyond R-Values: Understanding Insulation and Fenestration Criteria Compliance Path in Pennsylvania

by Christopher Hine on September 8, 2026

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Description

The 2021 IRC provides three main prescriptive compliance options for residential energy efficiency; we will focus on two of them: the Insulation and Fenestration Criteria Path (Section N1102.1.2) and the R-Value Alternative Path (Section N1102.1.3). This webinar explains the differences between these compliance methods and demonstrates how the U-factor path can be used to evaluate the thermal performance of complete building assemblies in Pennsylvania Climate Zones 4 and 5. Through practical calculation examples, participants will learn how to determine assembly U-factors, evaluate fenestration requirements, and verify compliance with Table N1102.1.2 while supporting energy efficiency, occupant comfort, and code-compliant building envelope design.

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Learning Objectives

- Identify the differences between the 2021 IRC Insulation and Fenestration Criteria Path (Section N1102.1.2) and the R-Value Alternative Path (Section N1102.1.3) and determine when each compliance method may be used for residential construction in Pennsylvania Climate Zones 4 and 5.
- Explain how assembly U-factors and fenestration performance criteria influence thermal envelope efficiency, occupant comfort, and residential energy consumption.
- Calculate assembly U-factors for common residential building envelope assemblies and determine compliance with the maximum assembly U-factor requirements of Table N1102.1.2.
- Evaluate residential wall, ceiling, floor, foundation, and fenestration assemblies for compliance with the 2021 IRC prescriptive energy code requirements and identify design strategies that improve thermal performance while maintaining code compliance.

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Why This Webinar?

- Most of those in the residential industry understand component R-values
- Most of those in the residential industry understand fenestration U-factors
- However, assembly U-factors can be tricky
- Both are allowed in Pennsylvania

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Why "R-Value" Isn't the Whole Story

90%

of Pennsylvania homes studied met the **ceiling R-value** requirement

49%

PA homes meeting the **ceiling assembly U-factor** requirement in Phase I

$18.7M

Annual energy-cost savings potential identified across seven states in the test

5

Source: DOE residential field studies, energycodes.gov, cited in 2021 IRC Energy Efficiency Commentary
https://www.energycodes.gov/sites/default/files/2022-11/Combined_Residential_Energy_Code_Field_Study_Report_Final%20v3.pdf

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Pennsylvania: Opportunity Left on the Table

$218/home

Phase I annual savings potential per home
Highest of the seven states studied

5.8%

Reduction in Pennsylvania's potential savings from Phase I to Phase III
Smallest improvement among the states that improved

$3.0M/yr

Potential annual savings remaining after Phase III
Pennsylvania reduced its potential savings by only $185,349 from the Phase I baseline

Pennsylvania started with the largest savings opportunity per home, but relatively little of that opportunity was captured during the study from Phase I and Phase III.

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Source: DOE residential field studies, energycodes.gov, cited in 2021 IRC Energy Efficiency Commentary
DOE Combined Residential Energy Code Field Study, Final Report (Pennsylvania: Performance Systems Development)
https://www.energycodes.gov/sites/default/files/2022-11/Combined_Residential_Energy_Code_Field_Study_Report_Final%20v3.pdf

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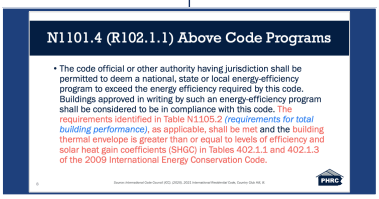
Energy Code Compliance Overview

2021 PA UCC Energy Compliance Options



Prescriptive

Performance

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N1101.4 (R102.1.1) Above Code Programs

- The code official or other authority having jurisdiction shall be permitted to deem a national, state or local energy-efficiency program to exceed the energy efficiency required by this code. Buildings approved in writing by such an energy-efficiency program shall be considered to be in compliance with this code. The requirements identified in Table N1105.2 *(requirements for total building performance)*, as applicable, shall be met and the building thermal envelope is greater than or equal to levels of efficiency and solar heat gain coefficients (SHGC) in Tables 402.1.1 and 402.1.3 of the 2009 International Energy Conservation Code.

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Source: International Code Council (ICC). (2020). 2021 International Residential Code, Country Club Hill, Ill.

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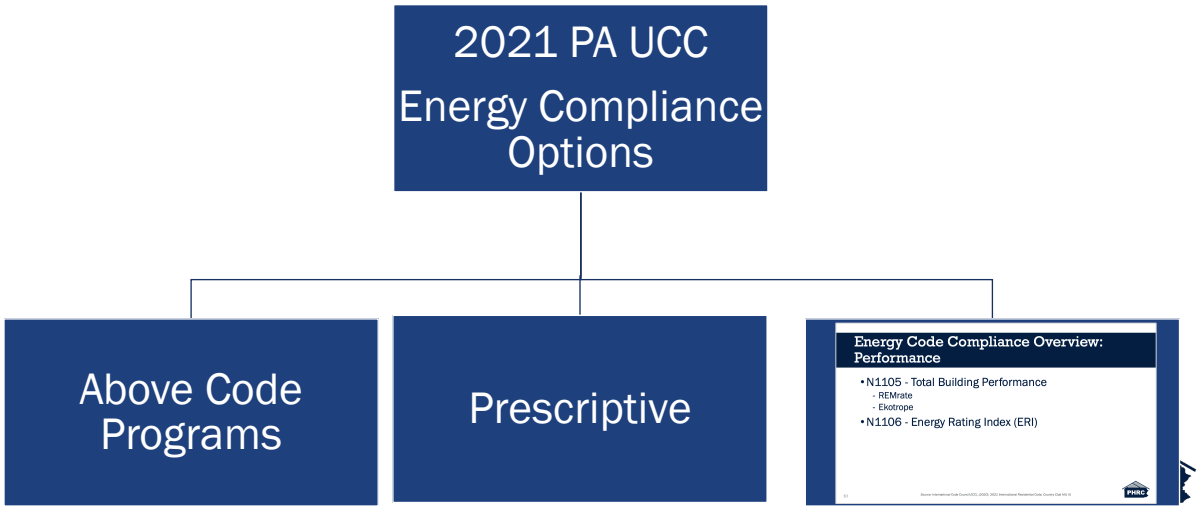
Energy Code Compliance Overview



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Energy Code Compliance Overview: Performance

- N1105 - Total Building Performance
  - REMrate
  - Ekotrope
- N1106 - Energy Rating Index (ERI)

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Source: International Code Council (ICC). (2020). 2021 International Residential Code, Country Club Hill, Ill.

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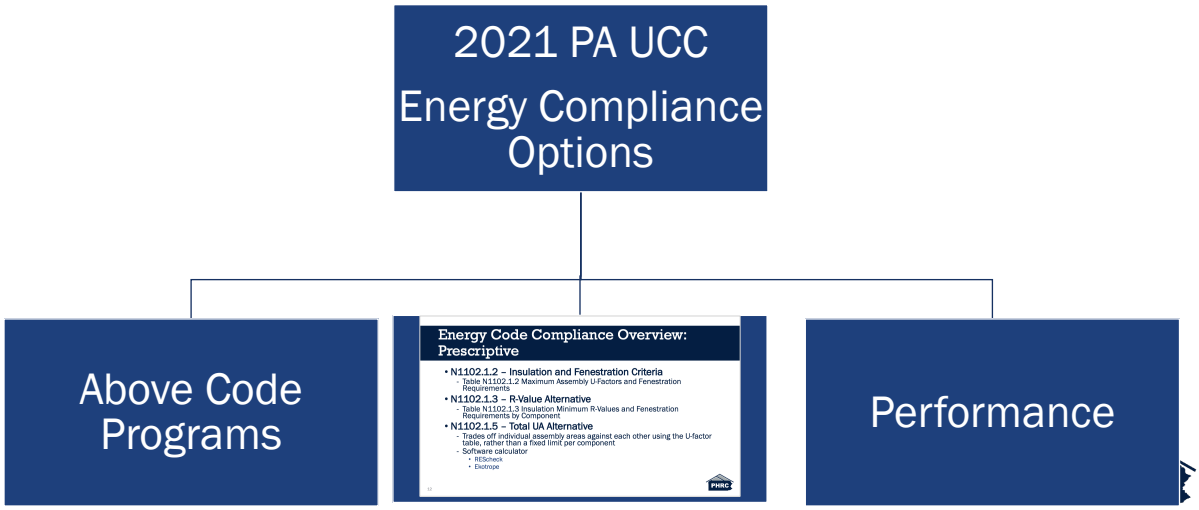
Energy Code Compliance Overview



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Energy Code Compliance Overview: Prescriptive

- N1102.1.2 – Insulation and Fenestration Criteria
  - Table N1102.1.2 Maximum Assembly U-Factors and Fenestration Requirements
- N1102.1.3 – R-Value Alternative
  - Table N1102.1.3 Insulation Minimum R-Values and Fenestration Requirements by Component
- N1102.1.5 – Total UA Alternative
  - Trades off individual assembly areas against each other using the U-factor table, rather than a fixed limit per component
  - Software calculator
    - REScheck
    - Ekotrope

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Three Prescriptive Compliance Paths

2021 IRC/IECC Prescriptive Path (as modified by the PA UCC)

N1102.1.3 R-Value Alternative	N1102.1.5 Total UA Alternative	N1102.1.2 Insulation & Fenestration Criteria
Least flexible: A direct, prescribed table lookup. Meet every listed R-value and you're done.	**Most flexible:** Trades envelope components against each other, but typically needs software to calculate.	**Often overlooked. Flexible AND straightforward once you know the math. This is today's focus.**

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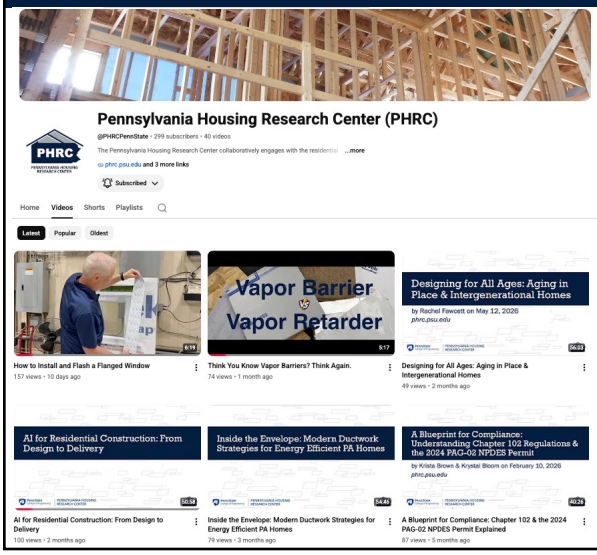
For More Compliance Path Information



- 2021 IRC Energy Code Compliance Options in Pennsylvania
- https://youtu.be/Z-OQPSdL-vA
- https://www.youtube.com/@PHRCPennState

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Prescriptive Compliance Path

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2021 IRC/IECC as Modified by the PA UCC

- The following tables can be found in the RAC Report
  - https://www.pa.gov/content/dam/copapwp-pagov/en/dli/documents/ucc/documents/2021%20icc%20code%20adoption%20final%20report.pdf

- TABLE N1102.1.2 (R402.1.2) MAXIMUM ASSEMBLY U-FACTORS[a] AND FENESTRATION REQUIREMENTS , is adopted as follows:

TABLE R1102.1.2 (R402.1.2)
MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT U-FACTOR	GLAZED FENESTRATION SHGC[d,e]	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR[b]	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.25	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.25	0.030	0.060	0.098	0.047	0.091	0.136
4 except Marine	0.30	0.55	0.40	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	NR	0.026	0.051	0.082	0.033	0.050	0.055
6	0.30	0.55	NR	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	NR	0.026	0.045	0.057	0.028	0.050	0.055

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. Mass walls shall be in accordance with Section N1102.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.
c. In warm-humid locations as defined by Figure R301.1 and Table R301.1, the basement wall *U*-factor shall not exceed 0.360.
d. The SHGC column applies to all glazed fenestration.
Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.
e. There are no SHGC requirements in the Marine Zone.

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i. Mass walls shall be in accordance with Section N1102.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.

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N1102.1.3 (R402.1.3) R-Value Alternative

- Assemblies with R-value of insulation materials equal to or greater than that specified in Table N1102.1.3 *(Insulation Minimum R-Values and Fenestration Requirements by Component)* shall be an alternative to the U-factor in Table N1102.1.2.

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Source: International Code Council (ICC). (2020). 2021 International Residential Code, Country Club Hill, Ill.

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Table N1102.1.3 Insulation Minimum R-Values and Fenestration Requirements by Component

TABLE N1102.1.3 (R402.1.3)
INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING R-FACTOR	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13 + 5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13 + 5[h]	8/13	19	10/13	10, 2ft	10/13
5 and Marine 4	0.30	0.55	NR	49	23 or 13 + 7.5[h] or 20 + 3.8[h]	13/17	30[g]	15/19	10, 4ft or 15, 3ft	15/19
6	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

Source: https://www.pa.gov/content/dam/copapwp-pagov/en/dli/documents/ucc/documents/2021%20icc%20code%20adoption%20final%20report.pdf

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N1102.1.2 (R402.1.2) Insulation and Fenestration Criteria:

- The building thermal envelope shall meet the requirements of Table N1102.1.2 *(Maximum Assembly U-Factors and Fenestration Requirements)* based on the climate zone specified in Section N1101.7. Assemblies shall have a U-factor equal to or less than that specified in Table N1102.1.2. Fenestration shall have a U-factor and glazed fenestration SHGC equal to or less than that specified in Table N1102.1.2.

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Source: International Code Council (ICC). (2020). 2021 International Residential Code, Country Club Hill, Ill.

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What is the Building Thermal Envelope?

- **BUILDING THERMAL ENVELOPE.** The basement walls, exterior walls, floors, ceilings, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

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Source: International Code Council (ICC). (2020). 2021 International Residential Code, Country Club Hill, Ill.

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Table N1102.1.2 Maximum Assembly U-Factors and Fenestration Requirements

TABLE R1102.1.2 (R402.1.2)
MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT U-FACTOR	GLAZED FENESTRATION SHGC[d,e]	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR[b]	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
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7 and 8	0.30	0.55	NR	0.026	0.045	0.057	0.028	0.050	0.055

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Source: https://www.pa.gov/content/dam/copapwp-pagov/en/dli/documents/ucc/documents/2021%20icc%20code%20adoption%20final%20report.pdf

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R-Value, U-Factor Conversion

- Thermal resistance (R-Value)
  - Thermal resistance
  - Higher R-value = greater resistance to heat flow
- Thermal transmittance (U-Factor)
  - Thermal transmittance
  - Lower U-factor = less heat transfer
- U-Factor = 1 / (R-Value); R-20 = U-.05 or U-.30 = R-3.33

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Not All Tables Are Equal

- Required Component R-value
  - CZ5 Wood Framed R-value
    - R-23 = U-.043



- Required Assembly U-factor
  - CZ5 Framed Wall U-factor
    - .051 = R-19.6

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Calculating Assembly U-Factors

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What Assemblies Will We Look At?

- Frame Wall Assembly Compliance
- Ceiling Assembly Compliance
- Floor Assembly Compliance
- Basement Wall Assembly Compliance
- Fenestration Compliance

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Frame Wall Assembly Compliance

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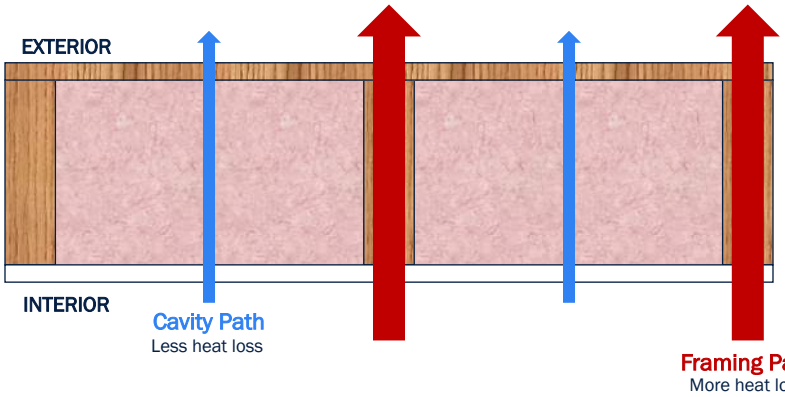
Anatomy of a Wall Assembly



Heat crosses every layer through these parallel paths: through the insulated cavity and through the wood studs/plates/headers. Each path has its own total R-value; that's the basis of the assembly U-factor calculation.

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The Parallel-Path Method

- A real wall is not one uniform material; it's several materials arranged side by side.
- Insulated cavities, framing members (studs, top/bottom plates), and headers each conduct heat differently.
- Each of these is a separate parallel path for heat flow, with its own total R-value.
- An assembly U-factor blends the paths together and is weighted by the area each one covers. This is typically referred to as the "framing factor".
- This is the method Table N1102.1.2 assumes when it lists a maximum assembly U-factor.

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What Is a Framing Factor?

- Framing Factor (2021 IRC/IECC, as Modified by the PA UCC): "The fraction of the total building component area that is structural framing."
- In a common 16″ o.c. wall, framing typically covers about 25% of the wall area.
- The remaining area (75%) is insulated cavity.
- More framing = less insulation = a higher assembly U-factor.
- This is why advanced framing and higher cavity R-values can help assemblies pass.

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Source: https://www.pa.gov/content/dam/copapwp-pagov/en/dli/documents/ucc/documents/2021%20icc%20code%20adoption%20final%20report.pdf

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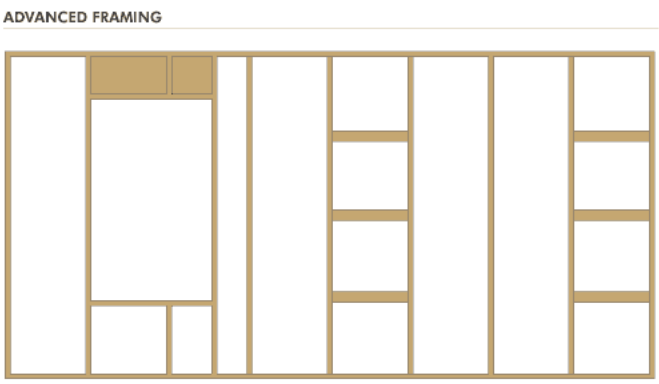
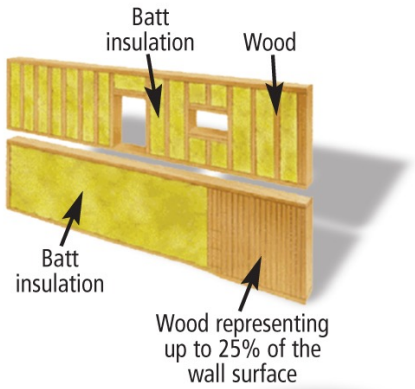
Visualizing the Framing Factor



Source: APA Advanced Framing Construction Guide (www.apawood.org)



Source: courtesy of "Thermal Bridge Free Construction"; Sam Hagerman

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Example Wall: Components & R-Values

Wall Component	Cavity R	Stud/Plate R	Header R
Outside air film	0.17	0.17	0.17
Vinyl siding (hollow backed)	0.62	0.62	0.62
OSB sheathing (7/16″)	0.62	0.62	0.62
Wood studs (2x6, R-1.25/in × 5.5″)	—	6.88	—
Cavity insulation	23.00	—	—
1/2″ drywall	0.45	0.45	0.45
Inside air film	0.68	0.68	0.68

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Source: ASHRAE. (2013). 2013 ASHRAE handbook: Fundamentals
Source: Insulation Values for Selected Materials, Colorado Energy: https://www.coloradoenergy.org/procorner/stuff/r-values.htm

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Step 1: Identify the Parallel Paths

- Every framed wall assembly is really three assemblies calculated side by side:
  - Cavity path — through the insulation between framing members
  - Framing (stud/plate) path — through the wood members themselves
  - Header path — through headers over doors and windows
- Each path shares the same exterior/interior layers (siding, sheathing, drywall, air films) but differs in what fills the middle.

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Step 2: Sum R-Values — Cavity Path

Layer	R-Value
Outside air film	0.17
Vinyl siding	0.62
OSB sheathing	0.62
Cavity insulation (R-23)	23.00
1/2″ drywall	0.45
Inside air film	0.68
Total R (cavity path)	**25.54**

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Step 3: Sum R-Values — Framing (Stud) Path

Layer	R-Value
Outside air film	0.17
Vinyl siding	0.62
OSB sheathing	0.62
Wood stud (5.5″ × R-1.25/in.)	6.875
1/2″ drywall	0.45
Inside air film	0.68
Total R (framing path)	**9.42**

Notice: No cavity insulation in this path. Solid wood conducts far more heat than the insulated cavity does.

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Step 4: Sum R-Values — Header Path

Layer	R-Value
Outside air film	0.17
Vinyl siding	0.62
OSB sheathing	0.62
Header framing (calculated as 3-ply header)	5.625
1/2″ drywall	0.45
Inside air film	0.68
Total R (header path)	**8.17**

No insulated header product was used in this example.

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Step 5: Convert R to U & Weight by Area

Path	Total R-value	Area %	U-factor = 1/R	Weighted U (% × U-factor)
Cavity	25.54	75%	0.0392	0.0294
Framing (studs)	9.42	20%	0.1062	0.0212
Header	8.17	5%	0.1224	0.0061

Each path's U-factor is weighted by the fraction of wall area it covers, then the weighted values are added together.

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Step 6: Add the Weighted U-Factors

0.0294 + 0.0212 + 0.0061

Assembly U-factor = 0.05673

This is the blended U-factor for the complete wall assembly — cavity, framing, and header paths combined.

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Step 7: Compare to Table N1102.1.2

Climate Zone	Max Frame Wall U-Factor	Calculated Assembly U-Factor
Climate Zone 4	0.060	0.05673
Climate Zone 5	0.051	0.05673

Table N1102.1.2 (R402.1.2), as adopted by the PA UCC — Maximum Assembly U-Factors and Fenestration Requirements

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Results: Does the Wall Assembly Pass?

Climate Zone 4	Climate Zone 5
0.05673 ≤ 0.060	0.05673 > 0.051
✓ PASS	✗ FAIL

This assembly (2x6 wall, R-23 cavity, standard framing) meets the U-factor path in Climate Zone 4, but falls short in Climate Zone 5, even though the R-23 value is passing in Table N1102.1.3 "Insulation Minimum R-Values and Fenestration Requirements by Component".

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What Would It Take to Pass CZ5?

- Add continuous insulation (CI)
  - CI reduces the U-factor of every path, including the framing and header paths
  - Adding just R-5 continuous insulation to the previous example drops the assembly U-factor from 0.0567 to about 0.0422
    - Comfortably passing Climate Zone 5
- Reduce the framing factor
  - Advanced framing techniques (24″ o.c. studs, single top plate, two-stud corners) shrink the framing area and grow the cavity area
  - Follow the prescribed path in Chapter 4 of the 2022 ANSI/RESNET/ICC 301 to achieve a 19% framing fraction
- Any combination of the above
  - Calculating the assembly lets you test changes instantly before committing to a design

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Sensitivity: What if Cavity Insulation Changes?

Cavity Insulation	Assembly U-Factor	CZ 4 (≤ 0.060)	CZ 5 (≤ 0.051)
R-19	0.0623	Fail	Fail
R-21	0.0592	Pass	Fail
R-23 (previous example)	0.0567	Pass	Fail
Flash & Batt (R-12 + R-15) & R-5 insulated headers	0.0504	Pass	Pass

All other components held constant (75/20/5 cavity/framing). Only cavity R-value and insulated header changes.

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U-Factor Path vs. R-Value Path

	R-Value Alternative Path (N1102.1.3)	Assembly U-Factor Path (N1102.1.2)
What it checks	Component insulation R-values are the primary compliance check	Whole assembly performance, including framing losses
Simplicity	Faster to check — no calculation needed	Requires calculating a blended U-factor
Best for	Standard framing & typical assemblies	Advanced framing, unusual assemblies, when you need flexibility
Accounts for framing losses?	No	Yes

The prescriptive R-value approach does not require the designer to calculate the actual framing fraction, while the U-factor approach accounts for the thermal performance of the complete assembly, including framing effects.

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The Calculator: Wood Framed Walls

- Let's Give it a Try!

2021 PA UCC Section N1102.1.2
Assembly U-Factor Calculator for Framed Wall Assemblies

Wall Component	R-Value	Thickness	Cavity R-value	Studs, Plates R-value	Headers R-value
Outside air film[1]	0.17		0.17	0.17	0.17
Vinyl siding (hollow backed)[1]	0.62		0.62	0.62	0.62
Lapped cement siding (1/4")[1]	0.21		0.00	0.00	0.00
Brick (4")[2]	0.44		0.00	0.00	0.00
Air Space (1/2"-4")[2]	1		0.00	0.00	0.00
Continuous insulation	0		0.0	0.0	0.0
Wood header	R-1.25/in.	4.50			5.625
Insulated header R-value	0				0.00
OSB sheathing (7/16")[1]	0.62		0.62	0.62	0.62
Plywood (1/2")[1]	0.79		0.00	0.00	0.00
Wood studs	R-1.25/in.	5.50		6.875	
Cavity insulation #1	20		20		
Cavity insulation #2	0		0		
1/2" drywall / Gypsum board[2]	0.45		0.45	0.45	0.45
5/8" dywall / Gypsum board[2]	0.56		0.00	0.00	0.00
Inside air film[1]	0.68		0.68	0.68	0.68
Sum of all R-values			22.54	9.42	8.17
Indicates cell that can be modified					
Wall Assembly Composition		Must equal 100%	Cavity %	Wood Frame %	Header %
		100%	78%	17%	5%
		Combined U-Factors	0.0346	0.0181	0.0061

Ceiling Assembly Compliance

Ceiling Assemblies: Two Common Conditions

- Ceilings often aren't always insulated to a uniform depth across the whole attic ceiling.
- **Full-depth insulation**: The majority of the attic, where blown or batt insulation reaches its full specified depth
- **Tapered insulation**: Areas near the eaves or low-slope roof edges where truss/rafter depth limits how much insulation fits
- The assembly U-factor calculation blends these two conditions the same way the wall calculation blends cavity, framing, and header paths

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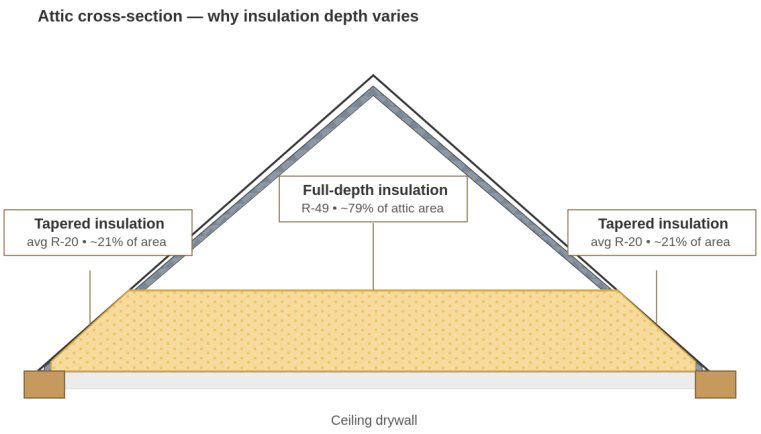
Visualizing the Attic Taper



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Example Ceiling: Components & R-Values

Ceiling Component	Full-Depth R	Tapered R
Full depth insulation (R-49)	49.00	—
Tapered insulation (average R-20)	—	20.00
1/2″ drywall	0.45	0.45
Inside air film	0.68	0.68
Total R-value	**50.13**	**21.13**

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Area Percentages & Weighted U-Factors

Path	Total R	Area %	U = 1/R	Weighted U (% × U)
Full-depth	50.13	79%	0.0199	0.0158
Tapered	21.13	21%	0.0473	0.0099

79% of the attic reaches full R-49 depth; 21% is limited by the roof/eave geometry with a value of R-20.

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Assembly U-Factor for the Ceiling

0.0158 + 0.0099

Assembly U-factor = 0.0257

This is the blended U-factor for the ceiling, combining the full-depth and tapered insulation areas.

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Results: Does the Ceiling Assembly Pass?

Climate Zones 4 & 5
0.0257 ≤ 0.026
✓ PASS — by a margin of just 0.0003

This ceiling passes. A slightly larger tapered-insulation area, or slightly lower average R-value in that area, could easily tip it into not passing.

Table N1102.1.2 (R402.1.2), as adopted by the PA UCC — Maximum Assembly U-Factors and Fenestration Requirements.

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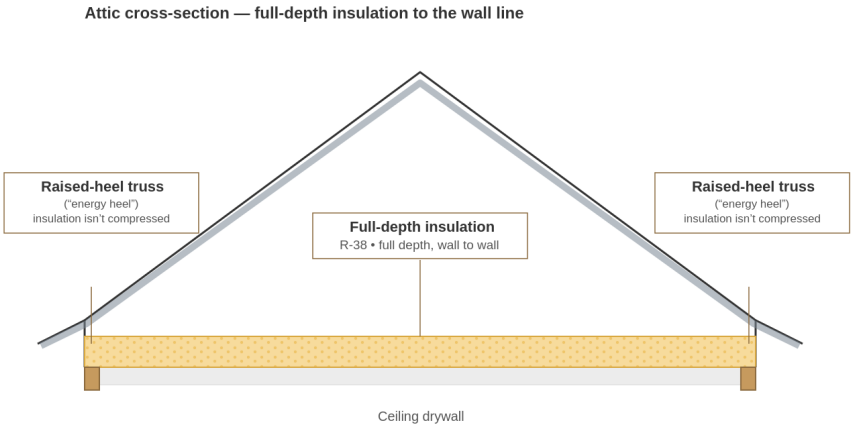
N1102.2.1 Ceilings with Attics

R-49 reduction to R-38



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The Calculator: Ceilings

- Let's Give it a Try!

2021 PA UCC Section N1102.1.2
Assembly U-Factor Calculator for Ceilings

Ceiling Component		Full Depth Insulation Assembly R-value	Tapered Insulation Assembly R-value
Full depth insulation	38	38	
Tapered insulation average	0		0.0
1/2" drywall / Gypsum board[2]	0.45	0.45	0.45
5/8" dywall / Gypsum board[2]	0.56	0.00	0.00
Inside air film[1]	0.68	0.68	0.68
Sum of all R-values		39.13	1.13
Indicates cell that can be modified			

Insulation thickness	Must equal 100%	Full Depth %	Tapered Average %
	100%	100%	0%
	Combined U-Factors	0.0256	0.0000
	Assembly U-Factor		0.02556

Does this Pass?		
Climate Zone 4 & 5 ≤ .02600	0.02556	Pass

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Floor Assembly Compliance

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Calculating Floor Assembly U-Factors

- A floor over unconditioned space (a garage, unconditioned basement / crawlspace or cantilever) is a parallel-path assembly, just like a wall
- Cavity path:
  - Through the insulation between the floor joists
- Framing (joist) path:
  - Through the joists themselves
- There is no header path in a typical floor. Rim joists and blocking are handled as their own detail (insulated to the wall above) and are left out of this simplified field calculation
- The same weighted-average method used for walls applies here: sum each path's R-value, convert to U-factor, then weight by the area each path covers

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Example Floor: Components & R-Values

Floor Component	Cavity R	Joist R
Interior air film (heat flow down)	0.92	0.92
Floor covering (carpet w/ pad)	2.08	2.08
3/4″ plywood subfloor	0.94	0.94
Cavity insulation (R-30 batt)	30.00	—
Floor joist (2x10, actual 9.25″ × R-1.25/in.)	—	11.56
Exterior air film (unconditioned space side)	0.17	0.17

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Source: ASHRAE. (2013). 2013 ASHRAE handbook: Fundamentals
Source: Insulation Values for Selected Materials, Colorado Energy: https://www.coloradoenergy.org/procorner/stuff/r-values.htm

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Floor: Sum & Weight of the Assembly U-Factor

Path	Total R	Area %	U = 1/R	Weighted U (% × U)
Cavity	34.11	90%	0.0293	0.0264
Joist (framing)	15.67	10%	0.0638	0.0064

Each path's U-factor is weighted by the fraction of floor area it covers, then the weighted values are added together. A floor's framing factor (10–13%) runs lower than a wall's (20–25%), since joists have fewer plates and no headers.

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Add the Weighted U-Factors

0.0264 + 0.0064

Assembly U-factor = 0.0328

This is the blended U-factor for the complete floor assembly — cavity and joist paths combined.

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Floor: Compare to Table N1102.1.2

Climate Zone	Max Floor U-Factor	Calculated Assembly U-Factor
Climate Zone 4	0.047	0.0328
Climate Zone 5	0.033	0.0328

Table N1102.1.2 (R402.1.2), as adopted by the PA UCC — Maximum Assembly U-Factors and Fenestration Requirements

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Results: Does the Floor Assembly Pass?

Climate Zone 4	Climate Zone 5
0.0328 ≤ 0.047	0.0328 ≤ 0.033
✓ PASS	✓ PASS

This assembly (2x10 joists, R-30 cavity) meets Climate Zone 4 but falls short in Climate Zone 5, the same pattern seen in the wall example.

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Basement Wall Assembly Compliance

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Basement Wall Assembly

- Basement wall insulation can be a combination of both continuous and cavity insulation.

2021 PA UCC Section N1102.1.2 Assembly U-Factor Calculator for Basement Walls				
Basement Wall Component	R-Value	Thickness	Cavity R-value	Studs R-value
Concrete wall (8", poured)[1]	0.64		0.64	0.64
Continuous insulation	5		5	5
Wood studs	R-1.25/in.	3.5		4.375
Cavity insulation	13		13	
1/2" drywall / Gypsum board[2]	0.45		0.45	0.45
Inside air film[1]	0.68		0.68	0.68
Sum of all R-values			19.77	11.145
Indicates cell that can be modified				
Basement Wall Composition		Must equal 100%	Cavity %	Stud %
		100%	85%	15%
		Combined U-Factors	0.0430	0.0135

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Sum R-Values: Cavity & Stud Paths

Layer	Cavity Path	Stud Path
Concrete wall (8″, poured)	0.64	0.64
Continuous insulation (R-5)	5.00	5.00
Wood stud (3.5″ × R-1.25/in.)	—	4.375
Cavity insulation	13.00	—
1/2″ drywall	0.45	0.45
Inside air film	0.68	0.68
Total R	**19.77**	**11.145**

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Weighting & Assembly U-Factor

Path	Total R	Area %	U = 1/R	Weighted U (% × U)
Cavity	19.77	85%	0.0501	0.0430
Stud	11.145	15%	0.0897	0.0135

0.0430 + 0.0135

Assembly U-factor = 0.05645

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Results: Does the Basement Wall Assembly Pass?

Climate Zone	Max Basement Wall U-Factor	Calculated Assembly U-Factor
Zone 4 (except Marine)	0.059	0.05645
Zone 5 and Marine 4	0.050	0.05645

Climate Zone 4
0.05645 ≤ 0.059
✓ PASS

Climate Zone 5
0.05645 > 0.050
✗ FAIL

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The Calculator: Basement Walls

- Let's Give it a Try!

2021 PA UCC Section N1102.1.2
Assembly U-Factor Calculator for Basement Walls

Basement Wall Component	R-Value	Thickness	Cavity R-value	Studs R-value
Concrete wall (8", poured)[1]	0.64		0.64	0.64
Continuous insulation	5		5	5
Wood studs	R-1.25/in.	3.5		4.375
Cavity insulation	13		13	
1/2" drywall / Gypsum board[2]	0.45		0.45	0.45
Inside air film[1]	0.68		0.68	0.68
Sum of all R-values			19.77	11.145
Indicates cell that can be modified				

Basement Wall Composition	Must equal 100%	Cavity %	Stud %
	100%	85%	15%
	Combined U-Factors	0.0430	0.0135



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Fenestration Compliance



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Fenestration Compliance: U-Factor & SHGC

- Table N1102.1.2 sets a maximum fenestration U-factor of 0.30 for both PA Climate Zone 4 and Climate Zone 5.
  - This is different than Table N1102.1.3, Insulation Minimum R-Values and Fenestration Requirements by Component
    - CZ4 = U.30
    - CZ5 = U.32
- Glazed fenestration SHGC is capped at 0.40 in Climate Zone 4 and is not regulated (NR) in Climate Zone 5.
- Every window, glass door, and skylight in the thermal envelope must meet these limits individually, unless the area-weighted averaging exception in Section N1102.5 is used (Total UA or Total Building Performance).

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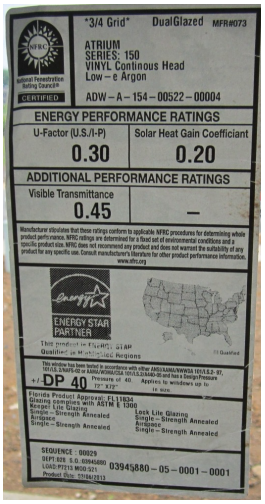
Fenestration Example: Does It Pass?

Climate Zone 4	Climate Zone 5
U-0.30 ≤ 0.30, SHGC 0.20 ≤ 0.40	U-0.30 ≤ 0.30, SHGC not regulated
✓ PASS	✓ PASS

Manufacturer NFRC labels report both U-factor and SHGC.



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Summary

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Common Mistakes in Assembly U-Factor Calculations

- Forgetting the header path. Headers over windows/doors are solid wood and often the weakest path in the assembly.
- Using a generic framing factor instead of the actual design. 24–25% framing is typical, but advanced or alternative framing practices can be much lower.
- Leaving out air films. Small individually (0.17 and 0.68), but required in every path.
- Applying continuous insulation to only the cavity path instead of all three paths.
- Comparing “component” R-value table (N1102.1.3) instead of the “assembly” U-factor table (N1102.1.2). They are two separate compliance paths with different limits.
- Not re-checking compliance after a late design change.

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Key Takeaways

- The 2021 IRC/IECC, as Modified by the PA UCC, offers two prescriptive paths: R-Value (N1102.1.3) and Insulation & Fenestration Criteria / U-factor (N1102.1.2)
- An assembly U-factor blends the cavity, framing, and header paths, weighted by the area each covers
- Framing losses can push an assembly over the limit, especially in Climate Zone 5
- Continuous insulation and advanced framing are the two most effective levers for lowering an assembly U-factor
- Flexibility!!

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Get the PHRC Calculator

- The U-Factor Assembly Calculator used in this webinar is a free PHRC resource.
- Includes tabs for wood framed walls, ceilings, floors, basement walls & crawlspace walls built around the PA UCC's adopted Table N1102.1.2 limits.
- Enter your own assembly components, thicknesses, and area percentages to get an instant pass/fail.
- Available on our website: phrc.psu.edu
- Questions about using the calculator for a specific project? Reach out to PHRC directly.

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Questions?

phrc.psu.edu

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Thank you for attending!

Check out the next webinar on:

Thursday, September 24 @ 11am ET

Tight Homes, Fresh Air: Balancing Air Sealing and Whole-House Ventilation
Darrin Wright, PHRC

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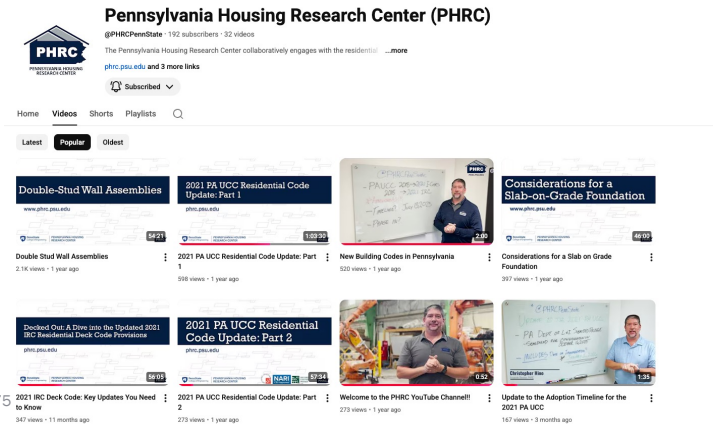

Beyond R-Values: Understanding Insulation and Fenestration Criteria Compliance Path in Pennsylvania

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