Foam Plastic Applications for Better Building

Continuous Insulation
RESOURCE GUIDE

FACTS Sheets & Quick Guides for Code-Compliant Applications of Foam Plastic Insulating Sheathing (FPIS)

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QUICK GUIDE
Foam Plastic Applications for Better Building

R-value Compliance Determinations: How to Appropriately Verify Building Wrap & Airspace Performance Claims

Before specifying a product, approving a building plan for permit, providing a building energy rating, or giving a "pass" on a field inspection, it is important to verify that materials providing the foundation for energy code compliance have a proper basis for any claimed or labeled R-value. Things may not actually be as they first appear. This Quick Guide provides some relevant background and important questions that can assist in ensuring that R-value data for insulation and other building products are valid.

BACKGROUND

This section provides examples of conditions where claimed R-values may warrant a carefully considered compliance determination following a 3-step process outlined in the next section. The examples involve airspaces, building materials, or a combination of these two components. These examples are not exhaustive and are provided as a basis for using informed judgment when considering the need for an R-value compliance determination.

The presence of an airspace enclosed within a building envelope assembly is known to contribute to the overall thermal performance of the assembly. However, the actual or design R-value of an airspace can vary significantly depending on various conditions of use, such as the air-tightness of the assembly of materials enclosing an airspace.[1]

Airspaces when sealed or enclosed generally provide an R-value of less than 1.[2] Values can be larger (e.g., R-2 to R-2.5) if the airspace is reflective and installation properly encloses an unventilated airspace in accordance with the tested[3] or pre-calculated R-value.[4] However, sometimes the claims put forward for products that rely on airspaces exceed what is physically possible or omit important installation conditions/limitations necessary to achieve the claimed R-value (see Figure 1).

Furthermore, some building wraps may claim high R-values without explicitly requiring installation of an airspace even though one or more sealed airspaces were included in the product's testing. Thus, you may see R-value claims as high as R-5 to R-6 for materials like a thin "thermal" building wrap. Under actual installation conditions, this type of product may at best provide about R-2 with an enclosed, unvented, and reflective airpace or as little as R-1 or less where such an airspace is not present (see Figure 2).

In short, if an R-value claim seems too good to be true, it very well may be.

Figure 1.

Reflective or non-reflective wrap with vented airspace behind brick or various other sidings that have air-permeable joints or weeps.

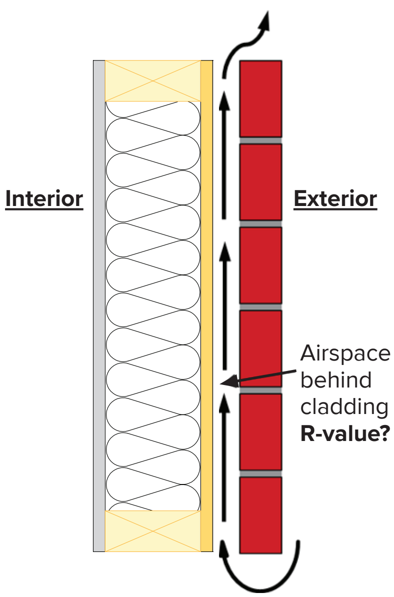
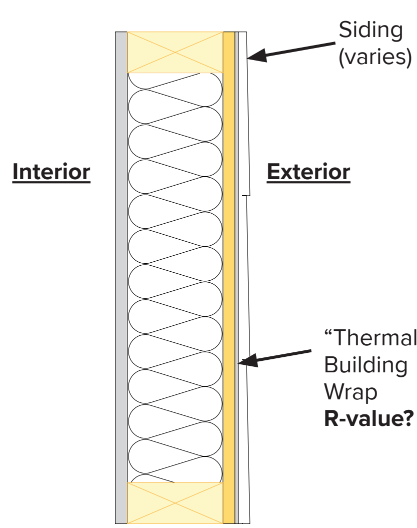


Figure 2.

Thin "thermal" building wrap.



[1] For additional information and research, refer to continuousinsulation.org/airspace-r-value.
[2] See ASHRAE Handbook of Fundamentals.
[3] ASTM C1363 assembly test.
[4] See ASHRAE Handbook of Fundamentals and ASHRAE 90.1 Appendix A, Section A9.4.2 and Table A9.4.2-1.

3 VERIFICATION STEPS TO INVESTIGATE THE VALIDITY OF AN R-VALUE CLAIM

1. VERIFY THE SOURCE

Is the identified R-value for a product certified by a credible third party?

Sections C303.1 and R303.1 of the International Energy Conservation Code (IECC) give authority to the code official to determine if an R-value for a given product is “identified in a manner that will allow a determination of compliance.” Where a material’s identified R-value is in question (see BACKGROUND section for examples), a determination of compliance should consider the manner by which the R-value is identified. For example, what is the source and is it credible?

Many U.S. insulation manufacturers employ an accredited third party to certify reported R-values and other material properties as a means of demonstrating compliance.[5] Credible third parties that certify building material properties for code compliance qualify as *approved sources* and/or *approved agencies* (as defined below) in U.S. model building and energy codes. In general, such entities operate in accordance with accepted standards for certification of products, which includes monitoring quality control and conformity of installation instructions (ISO/IEC 17065), testing (ISO/IEC 17025), and inspection (ISO/IEC 17020). In the U.S., approved sources and approved agencies are commonly accredited by ANAB[6] (or other similar entity) for building materials product certification.

Where the identified R-value for a product is not certified by a credible third party and remains questionable, it is advisable to continue to STEPS 2 and 3.

APPROVED SOURCE. An independent person, firm or corporation, *approved* by the *building official*, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests, furnishing inspection services or furnishing product certification where such agency has been *approved* by the *building official*.

2. CHECK THE TECHNICAL DATA

Is the technical basis for the identified R-value compliant with the code?

There must be a credible technical basis for the identified R-value associated with any product. The technical basis should include relevant test data, calculations, or published data from a credible source (see STEP 1). Such technical data is necessary to make a “determination of compliance.”

Where technical data complying with IECC Sections C303.1.4 and R303.1.4 is not available, it is not possible to make a determination of compliance. Therefore, the absence of such data should be the basis for a determination of non-compliance.

Where technical data is available or made available upon request, then the following questions should be investigated to support a determination of compliance or non-compliance:

- Were the required tests, calculations, or published data produced by an approved source, approved agency, or accredited third party[5] (see STEP 1)?
- Does the technical data include adequate information to make a determination that the test methods, calculations, or published data used to determine the R-value comply with IECC Sections C303.1.4 and R303.1.4?[7]
- Does the technical data clearly indicate the presence or absence of any deviation from the test methods, calculations, or published data required by IECC Sections C303.1.4 and R303.1.4?[7]
  - ▶ If deviations are found to exist they may render the data irrelevant, not consistent with accepted practice, or otherwise require coordination with installation conditions in a manner consistent with the deviations (see STEP 3).
- Does the test approach, calculations, or published data include materials or components other than the product itself, such as a sealed and enclosed airspace or other material layers?
  - ▶ If so, the R-value is not that of the product. Rather, the R-value respresents that of the system or assembly. Therefore, all of the tested components must be included in the installation instructions and the final installation to achieve compliance (see STEP 3).
  - ▶ Where systems or assemblies are used as the technical basis for an R-value, it typically does not qualify as a product R-value as used for R-value compliance. Instead, it may require compliance by means of a tested U-factor for the specific building envelope assembly conditions (see STEP 3).

[5] Requiring an accredited third party certification or testing of a product’s R-value is not an explicit code requirement except in the case of fenestration (see IECC Sections C303.1.3 and R303.1.3). However, it is a matter of code official discretion in applying the intent of Sections C303.1 and R303.1 of the IECC to materials other than fenestration.

[6] For additional information on ANAB, refer to anab.ansi.org.

[7] The required test methods or other technical bases for determining insulation product R-values are found in the Federal Trade Commission (FTC) R-value Rule (CFR Title 16, Part 460).

3. CHECK INSTALLATION DETAILS

Are the installation instructions and installed conditions consistent with the technical data investigated in STEP 2?

Finally, for a product to be used in a compliant manner, it is important to confirm that the manufacturer's installation instructions match the technical basis for determining the product's R-value as outlined in STEP 2. Several matters related to installation conditions were addressed in STEP 2 and, where found to be applicable, the product manufacturer's installation instructions should be obtained and verified to include all applicable installation conditions. The same installation conditions should also be verified as part of the inspection process during construction.

If one or more airspaces were included in the technical basis for a product's R-value (as determined in STEP 2), then it is particularly important that the installation instructions include those airspaces (including the presence of one or more reflective surfaces if applicable to the technical basis of the product's R-value).

In addition, it must be verified that the airspace is installed in accordance with code requirements for the construction of airspaces used to help comply with the code's building thermal envelope requirements. Such requirements are found in IECC Section C402.2.7 and Section R303.1.6, ASHRAE 090.1-2019 Section A9.4.2, and also in the ASHRAE Handbook of Fundamentals. In general, the airspace must be unventilated and enclosed on all sides.

If these questions check out, then it is likely that the R-value claim is legitimate. The main issue is to ensure installation in the field reasonably matches the basis for the claimed R-value.

Why is verifying material R-values important?

1. The energy conservation intent of the energy code[8] relies on the R-values of materials used for compliance.
2. Energy code compliance (for all compliance paths) depends on insulation material R-values complying with Chapter 3 of the IECC.
3. Building moisture control and durability performance required in the building code depends on the R-value of insulation materials[9] and this also carries potential health and safety implications over the useful life of the building related to the purpose of the building code.[10]
4. Energy use of commercial and residential buildings is fundamentally linked to the performance of insulation materials complying with the code.
5. The duties and powers assigned to the building official to enforce the provisions of the building code[11] includes energy conservation[10] and the approval of materials,[12] as well as the approval of alternative materials and methods as being equivalent to those specified in the code.[13]

[8] See IECC Sections C101.3 and R101.3.
[9] See IBC Section 1404.3 and IRC Section R702.7.
[10] See IBC Section 101.3 and IRC Section R101.3.
[11] See IBC Section 104 and IRC Section R104.
[12] See IBC Section 104.9 and IRC Section R104.9.
[13] See IBC Section 104.2.3, IRC Section R104.2.2, and IECC Sections C104 and R104.

Contact us.

Owned and operated by the Applied Building Technology Group with support from the Foam Sheathing Committee (FSC) of the American Chemistry Council, **continuousinsulation.org** provides informational resources intended to assist the foam plastic insulating sheathing industry, using sound science to develop research supporting the reliable, efficient, and economic design and installation of foam sheathing.

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Fire Safety & Moisture Protection for Wall Assemblies

Advantages for Code-Compliant Use of Foam Plastic Insulating Sheathing (FPIS) as Continuous Insulation (ci)

Fire safety and the control of water in its various forms are crucial to the creation of a wall assembly that is durable, safe, and code compliant. When using foam plastic insulating sheathing (FPIS) as continuous insulation (ci) for energy code compliance, two key wall performance considerations for building code compliance include **Fire Safety** and **Moisture Protection**.

FIRE SAFETY FIRST!

The combustibility of a specified continuous insulation material is not the sole factor that determines the fire performance of a building, its exterior wall system, or its exterior wall covering assembly. **Simply put, specifying a non-combustible insulation material does not ensure code-compliant fire safety.** This is why building codes comprehensively address fire-safety in an integrated manner for materials, assemblies, and building systems as a whole.

For foam plastic insulation materials, like FPIS, strict regulations have been in place since 1976. Current requirements for FPIS used in exterior walls for commercial buildings of Type I, II, III, and IV construction are covered in Section 2603.5 of the International Building Code (IBC). Additional requirements for use of combustible materials in exterior wall coverings are found in Section 1405. These provisions represent some of the most comprehensive, stringent, and effective fire-safety requirements for use of a combustible material on exterior walls of buildings of any height.

A key component of IBC Section 2603.5 is a full-scale, two-story wall fire test method known as the NFPA 285 standard. Many exterior wall assemblies including FPIS have successfully passed this test and are listed here. NFPA 285 has proven to be an effective indicator of acceptable fire performance since 1988. As evidenced by exterior fire events reported internationally, there is an absence of adverse life-safety protection consequences for buildings properly designed and constructed with (1) sprinklers and (2) either NFPA 285 or IBC Chapter 26 compliant exteriors using foam plastics or non-combustible exteriors. **Using NFPA 285-tested assemblies when specifying FPIS ci on buildings of Type I, II, III, and IV construction is a code requirement and it provides confidence in successful assembly performance consistent with actual experience.**

For all building types (including Type V buildings and homes of combustible wood frame construction that do not require NFPA 285-tested wall assemblies), FPIS products must comply with code-required maximum flame spread and smoke-developed indices in accordance with the long-standing ASTM E84 test method. Additional fire-safety features required by code include the use of thermal barriers (e.g., gypsum wall board) or ignition barriers to protect foam plastics from exposure to an interior fire or ignition source – the primary sources of fire risk for buildings. Manufacturers also are required to conduct full-scale fire tests for special approval of applications or conditions of use that are not specifically addressed by the code.

Source: Fire Safety & Foam Sheathing Use

Learn more: **FIRE PERFORMANCE**

MOISTURE PROTECTION IS IMPORTANT TOO!

The primary function of FPIS ci is to minimize structural thermal bridging and satisfy energy efficiency thermal insulation requirements. However, as a multi-functional material with many benefits, it also protects the building structure from the exterior environment by enabling a thermally stable and dry exterior wall, floor, or roof assembly. Furthermore, the use of FPIS ci can make indoor spaces more comfortable for occupants and aid HVAC system operation for healthy indoor environments.

When properly integrated into a wall assembly as discussed below, FPIS helps to protect buildings from the damaging effects of moisture by providing three things:

1. A durable **water-resistive barrier** system to prevent water intrusion and avoid "trapped" water.
2. Reliable **temperature control** to prevent condensation and moisture accumulation in materials by adsorption of water vapor.
3. Strategic use of **inward drying potential**, resulting in a wall that "breathes out" moisture to promote drying but does not "breathe in" moisture with seasonal changes in vapor drive direction.

WATER-RESISTIVE BARRIER (WRB):

FPIS ci can be used as a durable WRB system to eliminate the need for and cost of a separate WRB material. Code-approved FPIS WRB systems are listed here. FPIS WRB systems must pass the highest WRB water-resistance performance testing requirements as shown in this research report. Even when used with a separate WRB material, FPIS is recognized as a non-water absorbing material layer that protects a wall assembly from the exterior environment, including potentially severe inward vapor drives from moisture-reservoir claddings like stucco as well as anchored or adhered brick and stone veneers. Coupled with drainage provisions in the building code and proper installation, FPIS provides robust protection against water intrusion and entrapped water. Find more information on water-resistive barrier applications of FPIS here.

WATER VAPOR CONTROL:

Using FPIS ci on the exterior side of a wall assembly provides reliable temperature control for protection against condensation and moisture accumulation. All that is required is specification of the proper R-value of FPIS ci based on the climate, coupled with an appropriate interior vapor retarder (or even eliminating it), for maximum inward drying potential and thermal performance. Refer to these wall calculators for assistance with achieving energy code and water vapor control code compliance. Find more information on the use of FPIS to reliably control water vapor here.

DRYING POTENTIAL:

"The more 'breathability' the better" is a common misconception when it comes to walls, along with the idea that it can be achieved by simply placing a vapor permeable water-resistive barrier on the exterior side of any wall assembly. As with fire safety, actual moisture performance must be based on the assembly as a whole, not on any individual layer. Wetting and drying must be balanced with sufficient drying to the inward or outward direction of a wall depending on climate and how the wall was designed to manage moisture. Because water vapor drives switch directions seasonally, too much vapor permeability on one side of a wall at one time of the year can actually result in too much wetting at another time of the year. (Learn more about how walls breathe here). Because FPIS protects the wall assembly from the effect of these seasonally changing vapor drives and reliably retains properly balanced inward drying potential, it can strategically control water vapor in a manner suitable to all climates and virtually any wall assembly.

Learn more: **MOISTURE PROTECTION**

Content originally produced for continuousinsulation.org with support from ACC's Foam Sheathing Committee.

Building Thermal Envelope 101:
Identifying & Mitigating Thermal Bridges with FPIS ci

INTRODUCTION

Modern energy codes, such as ASHRAE 90.1-2022 and the 2024 IECC, feature prescriptive requirements for continuous insulation (ci) in essentially all climate zones. Among other benefits, ci helps to prevent thermal bridging caused by framing as visualized in **Figure 1**. Without ci, the wall's cavity insulation is only 45% to 85% effective[1] for steel and wood framing, respectively. Ci also compliments the thermal mass of concrete and masonry walls, especially in cold climates where thermal mass effects are much diminished. It also plays a key role in other building applications such as roofs, foundations, and various retrofit or remodeling projects.

The conventional practice of addressing thermal bridges only within building assemblies is not the end of the story. Other major types of thermal bridges occur at building assembly and component intersections as shown in **Figure 2**. If not mitigated, a building thermal envelope's actual performance (effective R-value) can be decreased by typically 20-70%, or more, depending on the building materials, structural details, and insulation detailing (or lack thereof).

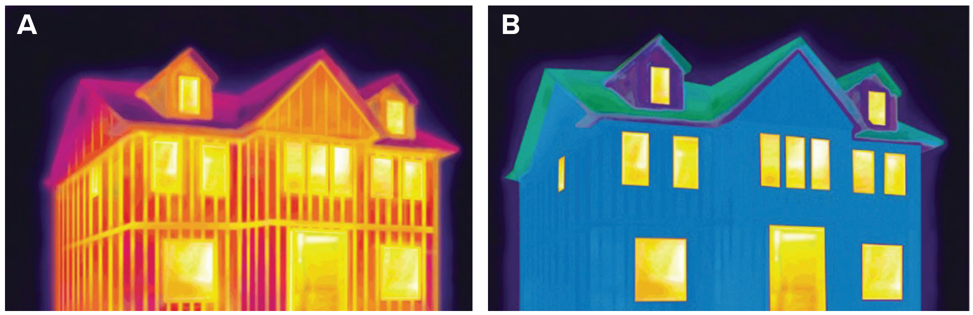
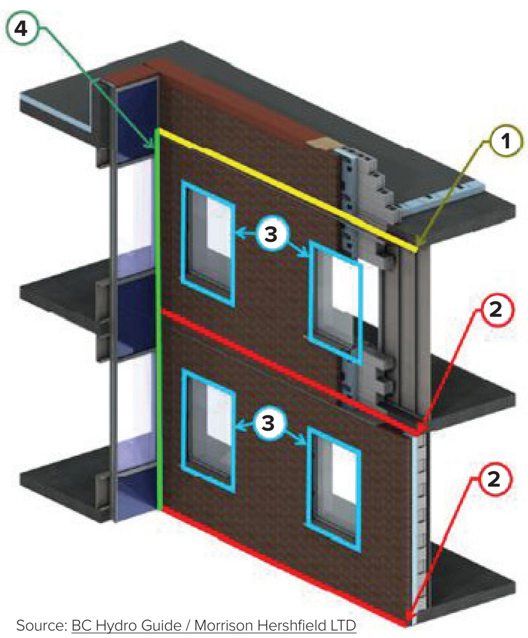


Figure 1. Thermal image illustration of (A) unmitigated thermal bridges with only cavity insulation between framing members and (B) use of ci to minimize thermal bridging. (Similar results can be expected in commercial buildings with and without ci.)



Source: BC Hydro Guide / Morrison Hershfield LTD

- **Clear field thermal bridges:** Repetitive framing members, cladding supports (e.g., Z-furring), and fasteners distributed relatively uniformly throughout a building assembly surface.[2]
- **Linear thermal bridges:** Roof-to-wall, floor-to-wall, window-to-wall, and wall-to-wall intersections that are linear in pattern of intensified heat flow (e.g., slab floor edges and projecting balconies, shelf-angles, parapets, etc.).

  See colored lines in figure:
  1 (yellow) = roof-to-wall linear thermal bridge
  2 (red) = floor-to-wall linear thermal bridge
  3 (blue) = window-to-wall linear thermal bridge
  4 (green) = wall-to-wall linear thermal bridge
- **Point thermal bridges:** Thermal bridges that occur at a discrete point on the surface area of the building thermal envelope assembly, such as a beam or column penetration.

Figure 2. Types of thermal bridges in building assemblies and assembly interfaces.

[1] Effective Insulation R-Values in Steel vs. Wood Framing, Building Enclosure Online, May 29, 2017.

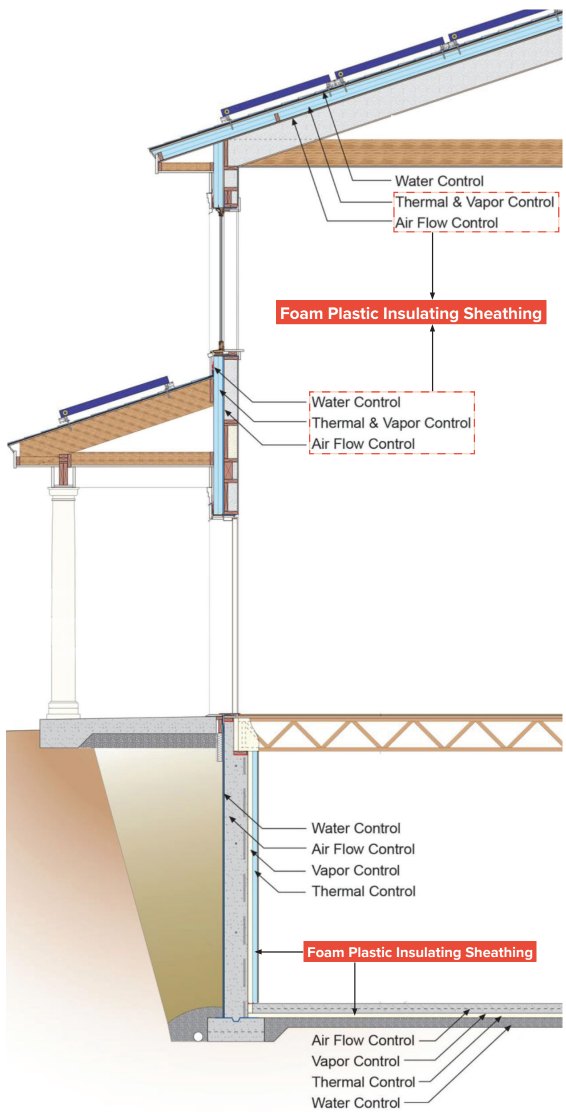
[2] According to the IECC and ASHRAE 90.1 definition of continuous insulation, the only permitted penetrations through continuous insulation are fasteners and service openings. Other penetrations, such as metal Z-furring (when not placed over the ci and fastened through it) are not permitted unless the impact on the assembly U-factor is accounted for.

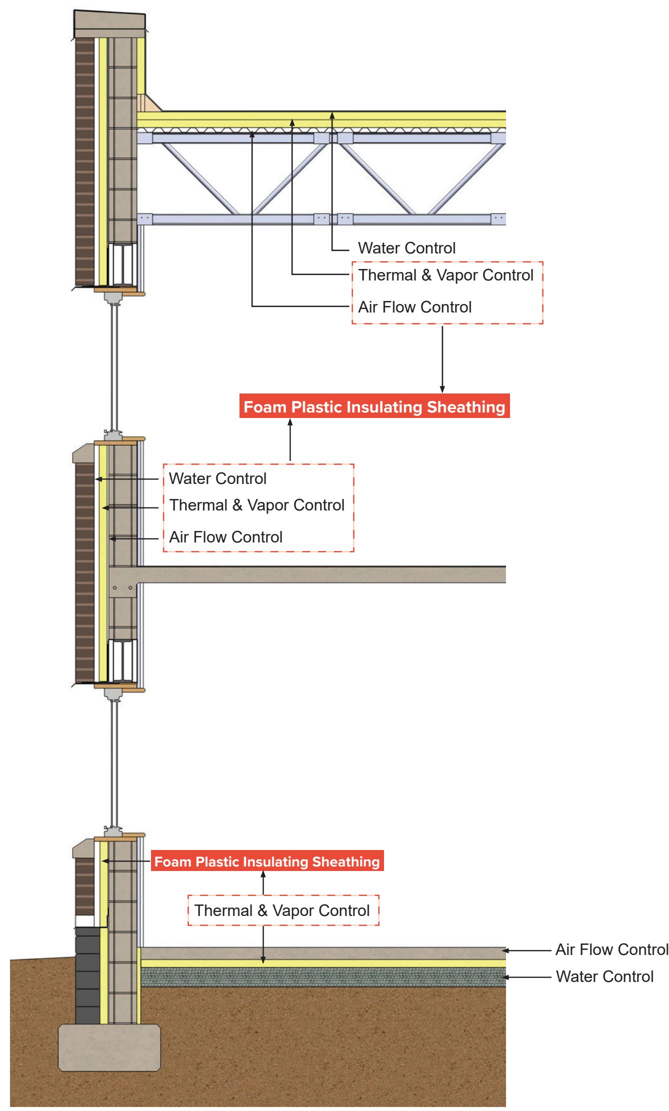
RESOURCES to Mitigate Thermal Bridges

Major thermal bridges at assembly interfaces have gone overlooked in past U.S. energy codes and practice. This is no longer the case in the pending 2024 IECC and the recently completed ASHRAE 90.1-2022 standard for commercial buildings. The following resources provide guidance for code compliance and best practices to mitigate thermal bridges:

- Thermal Bridging Prevention (web page with multiple resources listed).
- Thermal Bridging: Small Details with a Large Impact (educational presentation)
- Building Envelope Thermal Bridging (BETB) Guide (detailed design guide and data)
- Development of Thermal Bridging Factors for Use in Energy Models (design details and data)
- Thermal Performance of Façades (design details and data)
- BSI-081 Zeroing In and Construction Plans (details for high performance zero energy building continuous insulation)
- BSI-132 More on Continuous Exterior Insulation... (detailing cladding support fastening through ci)
- Cladding Connections through FPIS ci (solutions for cladding and furring attachments to minimize thermal bridging)

The following are example details used to mitigate thermal bridges at roof-to-wall, floor-to-wall, window-to-wall, and foundation conditions in both residential and commercial applications.





FACTS

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Moisture Control for Wall Assemblies:

Building Robust Walls with Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

RULE #1: Keep Water Vapor (Humid Air) Away from Cool Surfaces!

When installed in accordance with modern building code and energy code requirements for continuous insulation and water vapor control (see CI's Quick Guide: Water Vapor Control and wall calculators), FPIS ci keeps water-sensitive materials inside the wall dry by maintaining a temperature above the dew point. Simply use the right R-value of FPIS ci for the wall assembly based on the climate zone and an appropriately specified interior vapor retarder (or no interior vapor retarder) to control outward vapor diffusion in the winter and maintain inward vapor diffusion (drying) in the warmer seasons. This approach results in much dryer walls with a more stable moisture content throughout all seasons of the year in comparison to walls that rely exclusively on the traditional use of interior vapor retarders without any temperature control provided by FPIS ci, as shown in Figures 1 and 2. Learn more about the use of FPIS for water vapor control here.

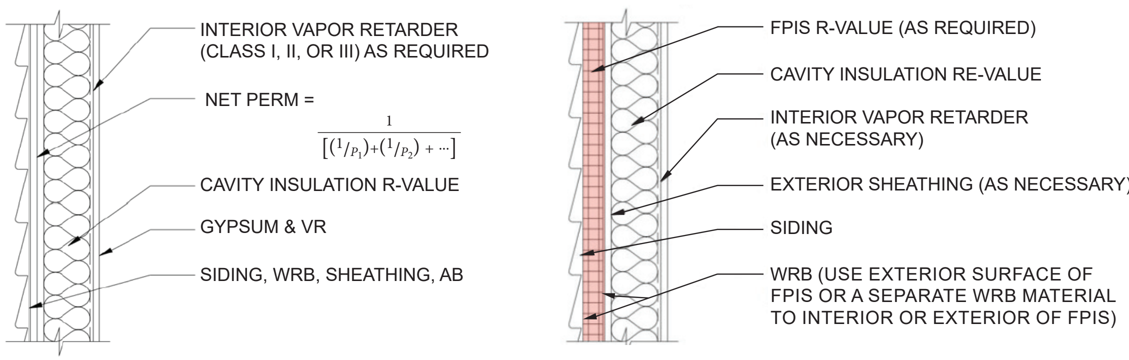
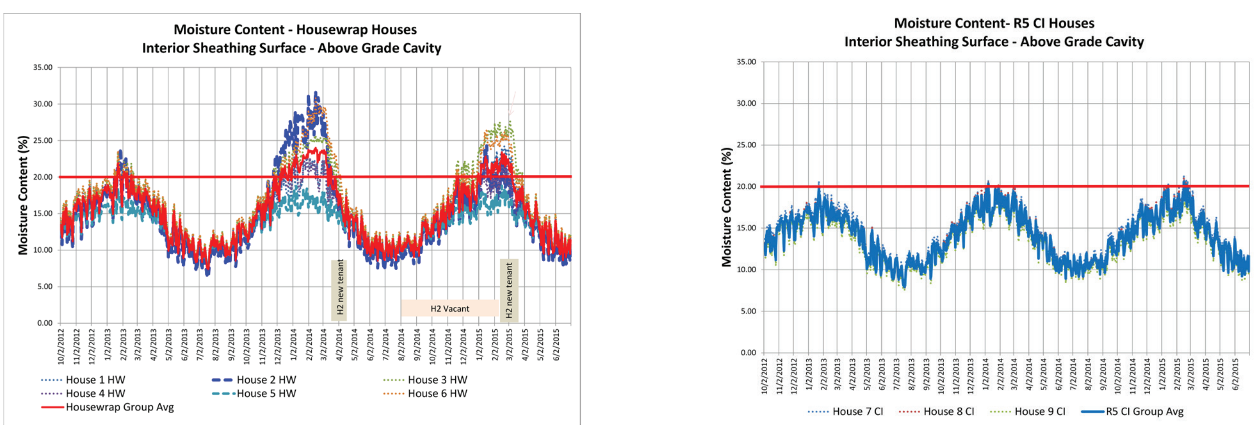


Figure 1. Cavity insulation only vs. wall with FPIS ci insulation (see Figure 2 for performance comparison)



(A) Walls with R20 cavity insulation only consistently experiencing wet OSB.

(B) Walls with R5 FPIS ci keeping OSB sheathing dry

Figure 2. Comparison of 12 actual walls with and without R5 FPIS ci

(Source: ABTG Educational Program)

RULE #2: Minimize Air Leakage!

Leakage of moist air from the indoors or outdoors into or through a building assembly can easily override the function of vapor retarders. Minimize air leakage by following energy code requirements for use of continuous air barriers and sealing of joints and gaps. It's not just an energy code concern (although it does save a lot of energy).

When RULE #1 is followed and the FPIS ci is installed per Figure 3 as a code compliant air barrier, walls are less vulnerable to the consequence of air leakage for two reasons: (1) the FPIS ci will help limit air infiltration from the exterior (especially if it is also used as the WRB system, see RULE #3), and (2) it will also reduce the potential for moist air to condensate on or be adsorbed by moisture-sensitive materials inside the wall because it controls the temperature of those materials. Find more information on use of FPIS as an air barrier here.

RULE #3: Avoid Rain Water Intrusion!

Most importantly, keep rain water out of walls by proper use of cladding, drainage, water-resistive barrier (WRB), and flashing as required by the building code and good practice. Many FPIS ci products can be used as a code-approved WRB system when installed in accordance with the manufacturer's installation instructions. Approved FPIS WRB systems use durable joint treatments (e.g., joint tapes) and flashing materials (e.g., adhered or fluid-applied flexible flashings) as shown in Figure 4. FPIS WRB systems are subject to some of the most stringent wall assembly water-resistance test requirements. Find more information on FPIS WRB systems here.

See also: General Installation Guidance
General Window Installation & Flashing Instruction

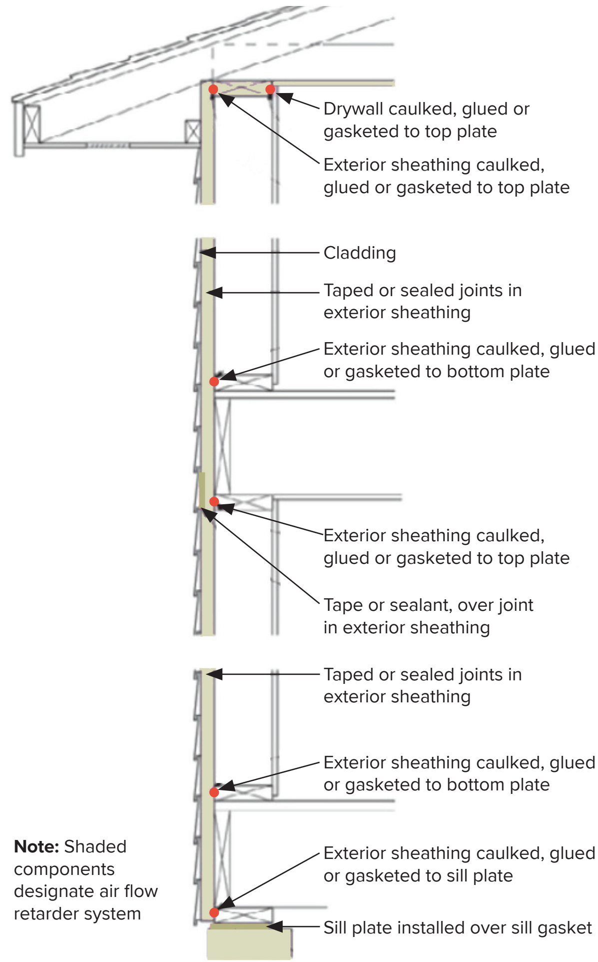


Figure 3. FPIS ci installed as an air barrier exterior sheathing.

(Source: BECP Building Energy Code Resource Guide Air Leakage Guide)

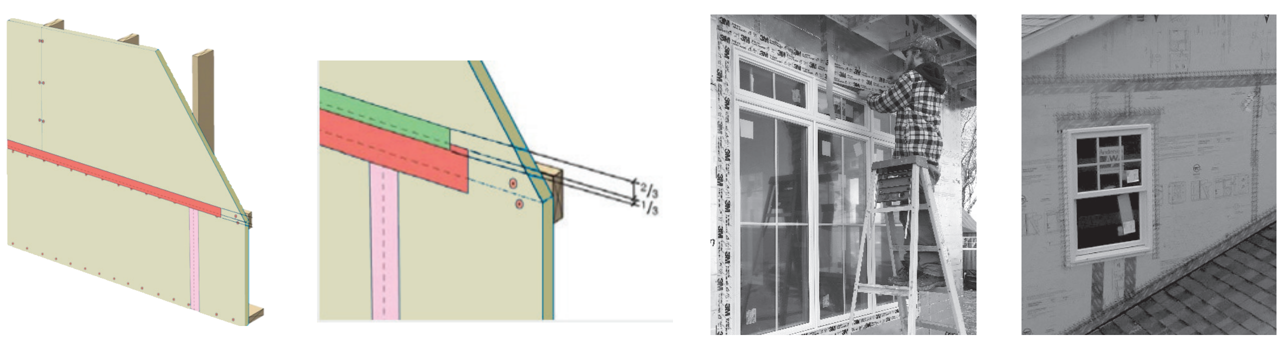


Figure 4. FPIS WRB System installation using joint tapes and adhered flashings; refer to manufacturer installation instructions for specific details.

BOTTOM LINE: Use FPIS ci as continuous insulation, vapor control, air barrier, and water-resistive barrier to create an efficient, robust, and moisture-resistant wall assembly for optimal performance and code compliance.

QUICK GUIDE
Foam Plastic Applications for Better Building

3 STEPS FOR CODE-COMPLIANT USE OF WATER VAPOR RETARDERS and Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

This reference guide summarizes key requirements and options in the 2024 International Residential Code (IRC) and 2024 International Building Code (IBC) for design and construction of code-compliant and moisture-resistant frame walls using foam plastic insulating sheathing (FPIS) as continuous insulation (ci). When used in a code-compliant manner, FPIS ci protects walls against the effects of moisture by keeping walls warm to prevent condensation while maximizing drying to the interior with proper vapor retarder specification.

Follow the three steps below for code-compliant water vapor control. The wall assembly design must also be coordinated with minimum energy code insulation requirements. For greater flexibility and to automate the application of this reference guide and energy code compliance, refer to these wall calculators. Various moisture control research reports and other practical guides are also available here.

For a summary of key concepts and principles for moisture control, refer to FACTS: Moisture Control for Wall Assemblies.

STEP 1: KNOW INTERIOR VAPOR RETARDER CLASSES

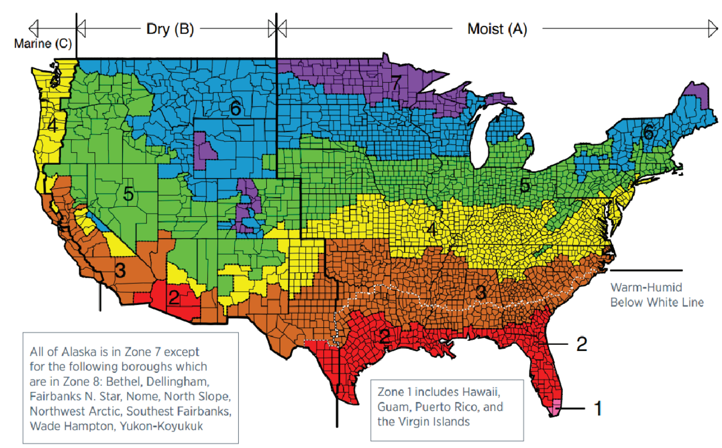
Use the following definitions for water vapor retarder classes when specifying interior vapor retarders in accordance with Steps 2 and 3:

TABLE R702.7(1) VAPOR RETARDER MATERIALS AND CLASSES

CLASS	ACCEPTABLE MATERIALS
I	Sheet polyethylene, nonperforated aluminum foil, or other approved materials with a perm rating of less than or equal to 0.1.
II	Kraft-faced fiberglass batts, vapor retarder paint, or other approved materials applied in accordance with the manufacturer's installation instructions for a perm rating greater than 0.1 and less than or equal to 1.0.
III	Latex paint, enamel paint, or other approved materials applied in accordance with the manufacturer's installation instructions for a perm rating of grater than 1.0 and less than or equal to 10.0.

STEP 2: CONSIDER PERMITTED INTERIOR VAPOR RETARDERS

Select a "permitted" vapor retarder for the interior side of frame walls based on the Climate Zones as outlined in IRC Table R702.7(2), paying attention to footnotes and other table references. In Climate Zones 4-8, no interior vapor retarder is required where complying with Table R702.7(5).



U.S. Climate Zones

RESPONSIVE VAPOR RETARDER is defined as a "material complying with a *vapor retarder class* of Class I or Class II but which also has a vapor permeance of 1 perm or greater in accordance with ASTM E96, water method (Procedure B)."

TABLE R702.7(2) VAPOR RETARDER OPTIONS

CLIMATE ZONE	VAPOR RETARDER CLASS		
	CLASS I[a]	CLASS II[a]	CLASS III
1, 2	Not Permitted	Not Permitted	Permitted
3, 4 (except Marine 4)	Not Permitted	Permitted[c]	Permitted
Marine 4, 5, 6, 7, 8	Permitted[b]	Permitted[c]	See Table R702.7(3)

a. A responsive vapor retarder shall be allowed on the interior side of any frame wall in all climate zones.

b. In frame walls, use of a Class I interior vapor retarder that is not a responsive vapor retarder on the interior side with a Class I vapor retarder on the exterior side shall require an approved design.

c. Where a Class I or II vapor retarder is used in combination with foam plastic insulating sheathing or insulated siding installed as continuous insulation on the exterior side of frame walls, the continuous insulation shall comply with Table R702.7(4) and the Class I or II vapor retarder shall be a responsive vapor retarder.

STEP 3: DETERMINE MINIMUM R-VALUE REQUIREMENTS FOR CI

For use of FPIS ci with Class I, II or III interior vapor retarders (per Step 2), determine the minimum ci R-value required to control water vapor using IRC Tables R702.7(3) or R702.7(4) as applicable. For use of FPIS without any interior vapor retarder, refer to Table R702.7(5) and its footnotes. The ci and cavity insulation amounts provided must also comply with local energy code.

TABLE R702.7(3) CLASS III VAPOR RETARDERS

(only requirements for ci are shown)

CLIMATE ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR:
4 Marine	ci with R-value ≥ 2.5 over 2 x 4 wall
	ci with R-value ≥ 3.75 over 2 x 6 wall
5	ci with R-value ≥ 5 over 2 x 4 wall
	ci with R-value ≥ 7.5 over 2 x 6 wall
6	ci with R-value ≥ 7.5 over 2 x 4 wall
	ci with R-value ≥ 11.25 over 2 x 6 wall
7	ci with R-value ≥ 10 over 2 x 4 wall
	ci with R-value ≥ 15 over 2 x 6 wall
8	ci with R-value ≥ 12.5 over 2 x 4 wall
	ci with R-value ≥ 20 over 2 x 6 wall

TABLE R702.7(4) CONTINUOUS INSULATION (ci) WITH CLASS I or II RESPONSIVE VAPOR RETARDER

CLIMATE ZONE	PERMITTED CONDITIONS
3	ci with R-value ≥ 2
4, 5, 6	ci with R-value ≥ 3 over 2 x 4 wall
	ci with R-value ≥ 5 over 2 x 6 wall
7	ci with R-value ≥ 5 over 2 x 4 wall
	ci with R-value ≥ 7.5 over 2 x 6 wall
8	ci with R-value ≥ 7.5 over 2 x 4 wall
	ci with R-value ≥ 10 over 2 x 6 wall

TIP: While not required, using more than the code minimum ci R-values shown above will further improve water vapor control and protection of the building envelope.

TABLE R702.7(5) CONTINUOUS INSULATION (ci) ON WALLS WITHOUT A CLASS I, II OR III INTERIOR VAPOR RETARDER[a]

CLIMATE ZONE	PERMITTED CONDITIONS[b,c]
4	ci with R-value ≥ 4.5
5	ci with R-value ≥ 6.5
6	ci with R-value ≥ 8.5
7	ci with R-value ≥ 11.5
8	ci with R-value ≥ 14

a. The total insulating value of materials to the interior side of the exterior continuous insulation, including any cavity insulation, shall not exceed R-5. Where the R-value of materials to the interior side of the exterior continuous insulation exceeds R-5, an approved design shall be required.

b. A water vapor control material layer having a permeance not greater than 1 perm in accordance with ASTM E96 Procedure A (dry cup) shall be placed on the exterior side of the wall and to the interior side of the exterior continuous insulation. The exterior continuous insulation shall be permitted to serve as the vapor control layer where, as its installed thickness or with a facer on its interior face, the exterior continuous insulation is a Class I or II vapor retarder.

c. The requirements in this table apply only to insulation used to control moisture in order to allow walls without a Class I, II or III interior vapor retarder. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of the *International Energy Conservation Code*.

NOTE: When using a Class I or II interior vapor retarder, it must comply with the "smart" or responsive vapor retarder requirements of footnote 'c' of IRC Table R702.7(2) above (e.g., coated kraft paper facer is a Class II responsive vapor retarder; Class I responsive vapor retarders are typically proprietary films or membranes). Responsive vapor retarders prevent OUTWARD moisture movement into walls in the winter and become vapor permeable for increased INWARD drying potential in the summer, which compliments the "warm wall" water vapor control provided by FPIS ci. A Class III interior vapor retarder is sufficiently vapor permeable at all times such that it is not required to be a "smart" vapor retarder but it requires more FPIS ci (i.e., a warmer wall) to prevent condensation in the winter.

YOU'RE DONE! For additional guidance on details and options for code-compliant moisture control, refer to this wall assembly illustration.

Contact us.

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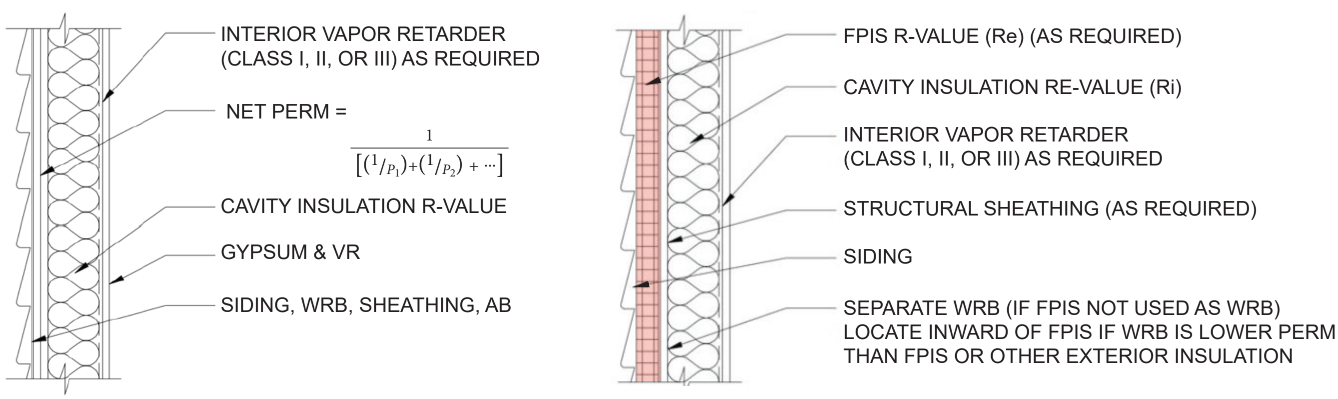
2x4 vs. 2x6 Walls:
Getting the Most Bang for Your Buck with Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation

Is it time to consider returning to a modern version of 2x4 walls?

Are you interested in reducing the cost of wood framing and minimizing the construction cost impact of lumber price volatility as occurred in 2020? One viable solution is 2x4 framing with cavity + continuous insulation instead of 2x6 framing with cavity-only insulation (see Figure 1 and Table 1). When compared to 2x6 framing, traditional 2x4 framing reduces framing wood fiber usage by as much as one-third with potential for similar framing cost savings. While both walls comply with minimum building and energy code requirements, the 2x4 wall constructed with foam plastic insulating sheathing (FPIS) continuous insulation (ci) provides better energy savings and moisture control performance (see Table 2 and Figure 2).



(A) 2x6 R20 Cavity Insulation Wall **(B) 2x4 R13+5ci Cavity + FPIS ci**

Figure 1. Wall Construction Options 2x6 vs. 2x4

Table 1. Comparison of 2x6 and 2x4 Wall Construction[1]

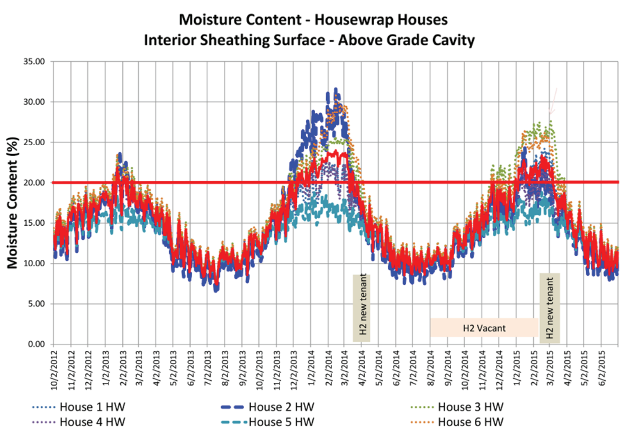
Item for Comparison	2x6	2x4	Result
Framing Cost	$$$	$$	2x4 less costly/less wood (verify local lumber pricing)
Framing Code Compliance			
1 story (16"oc or 24"oc)	YES	YES	Both comply, 2x4 uses less wood
2 story (16"oc)	YES	YES	Both comply, 2x4 uses less wood
Wall Bracing	YES	YES	Both comply, no difference
Wall Headers	YES	YES	Both comply, no difference
Energy Code Compliance[2]			
Climate Zone Applicability	1-5	1-5	Both comply in same climates
R-value (warm climates)	R20	R13+5ci	Both comply but R13+5ci is more efficient (lower U-factor)
R-value (mixed/cold climates)	R20+5ci	R13+10ci	Both comply and R13+10ci improves moisture control in very cold climates
Air barrier	Wrap w/tape	FPIS w/tape	Both comply
Water & Vapor Control Code Compliance[2]			
Water-resistive barrier (WRB)	Felt/Wrap/Other	FPIS w/tape	Both comply, FPIS w/tape higher performing (see Table 2)
Vapor Retarder	Varies by climate	Varies by climate	FPIS has better water vapor performance (see Figure 2)

[1] Comparison based on 2012-2024 International Residential Code; local codes will vary.
[2] Use these wall calculators to coordinate and optimize compliance with energy code insulation requirements and building code water and vapor control requirements.

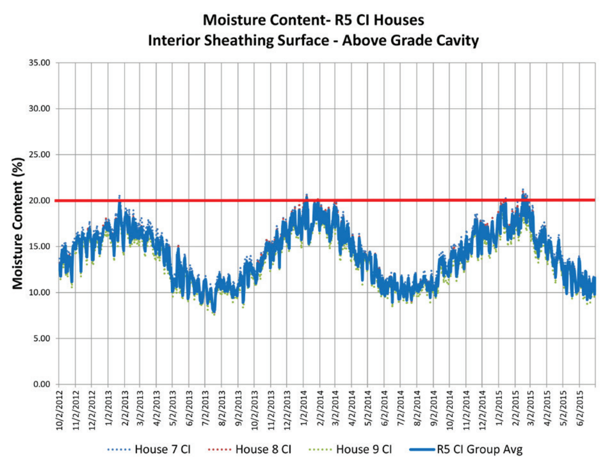
Table 2. Comparison of Water Resistance of FPIS WRB System to Other WRB Materials as Installed

WRB Type	Assembly Water-Resistance Performance (ASTM E331 wind-driven rain test)		Comparison
	Test Pressure	Test Duration	
FPIS WRB systems	6.24 psf	2 hours	FPIS WRB systems meet a higher performance standard than other code-minimum WRB types
Other WRB types (felt, wraps, coatings, etc.)	3.0 psf (if required)	15 minutes (if required)	

Source: ABTG Research Report 1504-03



(A) Walls with R20 cavity insulation only consistently experiencing wet OSB.



(B) Walls with R5 FPIS ci keeping OSB sheathing dry

Figure 2. Comparison of 12 actual walls with and without R5 FPIS ci

For supporting data and technical information, refer to CI's Water Vapor Control web page and ABTG Research Report 1410-03.

1. Both walls comply with minimum energy code and building code requirements, but the wall with R5 FPIS ci provides better moisture control.
2. Adding more FPIS ci relative to cavity insulation improves moisture-control performance in any climate zone and is a move toward the "perfect wall."
3. Refer to these wall calculators to support the good performance and code-compliance of wood frame and steel frame walls.

WINDOW INSTALLATION INSTRUCTIONS FOR WALLS WITH CONTINUOUS INSULATION:

Integral Nail-Flange Windows on Walls with Maximum 1½"-Thick Foam Plastic Insulating Sheathing (FPIS)[1]

IMPORTANT! READ ALL INSTRUCTIONS BEFORE BEGINNING INSTALLATION

STEP 1: KNOW YOUR RESPONSIBILITIES

The user of this document is responsible for the following: (1) determining the suitability of this document for the intended use; (2) complying with the local building code; (3) providing the necessary skill to execute a proper window installation; (4) following the component manufacturers' installation instructions for the user-specified window product, flashing materials, water-resistive barrier (WRB), foam plastic insulating sheathing (FPIS), sealants, and other materials as required for a complete an effective installation; and (5) addressing any variances from manufacturers' instructions and product warranty stipulations, including consultation with the applicable product manufacturers or a design professional as needed.

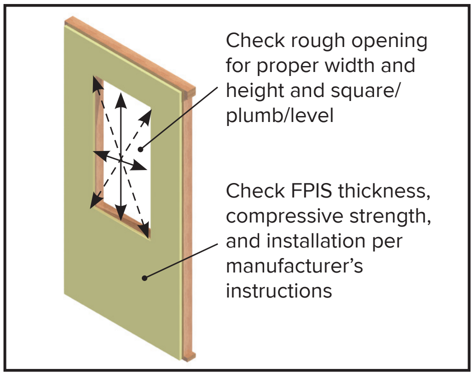


Figure 1. Rough opening and FPIS verification.

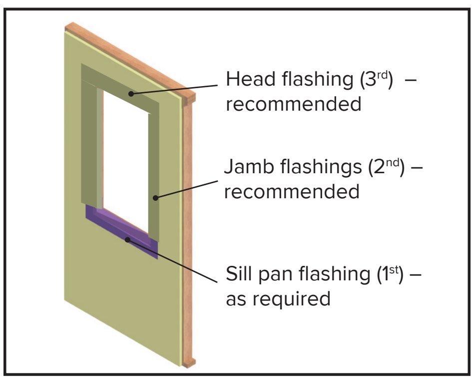


Figure 2. Install rough opening flashing, lapping shingle-fashion (bottom to top of opening).

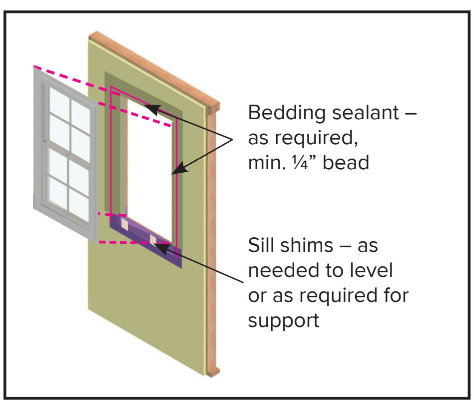


Figure 3. Apply sill shims and bedding sealant, set window into center of opening, and temporarily secure with flange nail.

STEP 2: BEFORE YOU INSTALL THE WINDOW

a. Verify that the rough opening is level, plumb, square, and the size required for the specified window product plus clearance for a rough opening gap as recommended by the window manufacturer (typically the rough opening width and height are ½" to ¾" greater than the window unit dimensions). See Figure 1.

b. Verify that the FPIS is not greater than 1½" thick, has a minimum compressive strength of 15 psi per ASTM C578 or ASTM C1289, and is installed in accordance with the FPIS manufacturer's installation instructions for a code-compliant WRB application. Where a separate WRB material is provided, the thickness of FPIS is greater than 1½", or for other special conditions, refer to the section **SPECIAL CONDITIONS & ADDITIONAL RESOURCES**.

c. Window sill pan flashing with back-dam, rough opening jamb flashings, and head flashings are a recommended installation best practice. Where used or required, install the rough opening flashing elements in shingle-lap fashion (see Figure 2). **NOTE:** Self-adhering and fluid-applied flexible flashings (or equal) are typically used for this purpose. Verify that the rough opening size can accommodate the additional thickness of flashing materials and maintain the required rough opening gap (see Item a).

STEP 3: INSTALLING THE WINDOW

a. Apply the window manufacturer's recommended bedding sealant (min. ¼" bead) to the rough opening perimeter approximately ½" to ¾" from the edge of the rough opening (see Figure 3). **DO NOT** apply bedding sealant to sill flange where sill pan flashing is used (see Step 2, Item c).

b. Where sill shims are required by the manufacturer or where the sill is not level, shims may be placed and tacked into level position prior to setting the window unit. See Figure 3.

c. With the window closed and in locked position, set into the center of the rough opening and fasten the center nail hole of the top flange to the rough opening with the manufacturer's recommended flange fastener, or initially secure as otherwise recommended by the manufacturer (See Figure 3). Verify that the required gap between the window head and header is present.

d. Install sill shims (if not previously installed) and jamb shims at locations as required by window manufacturer. Adjust shims as necessary to achieve a square, plumb, and level window installation. Apply shims at window head only where required by the manufacturer.

e. Check operation of the window and then install remaining nail flange fasteners as recommended by the manufacturer. A maximum fastener spacing of 6" is recommended. **NOTE:** The length of fasteners will need to accommodate the thickness of FPIS and maintain the required penetration into rough opening framing materials. Do not over- or under-drive flange fasteners. Flanges should be firmly

[1] For thicker foam sheathing and other special conditions, refer to section "SPECIAL CONDITIONS & ADDITIONAL RESOURCES"

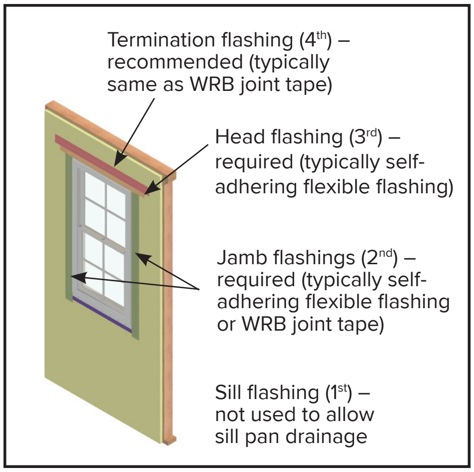


Figure 4. After permanently securing the flange, install exterior flashing in shingle fashion (bottom to top) on sill, jamb, and head flanges and to WRB surface. DO NOT apply sill flashing if rough opening sill pan is installed (as shown).

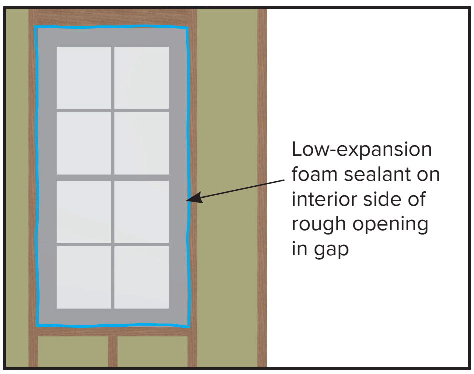


Figure 5. Air seal the interior side of the rough opening gap with low-expansion foam sealant.

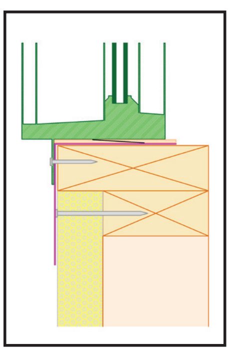


Figure 6.
Rough opening "window buck"

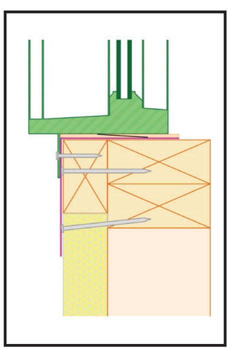


Figure 7.
Rough opening "picture frame"

bedded in sealant and not warped out of plane. Clean off any excess sealant. Install any additional frame anchorage as required by the window manufacturer.

f. Apply exterior flashing per manufacturer's instructions to window perimeter in shingle-lap fashion, starting at the bottom and ending with the head flashing (see Figure 4). **DO NOT** install flashing over flange at sill where a sill pan has been installed in the rough opening. Use compatible flashing materials recommended by the window manufacturer or WRB manufacturer and ensure conditions are appropriate for application (clean, dry, suitable temperature, etc.). **NOTE:** Self-adhering and fluid-applied flexible flashings (or equal) are typically used for this purpose and must have sufficient width to lap window flange and extend a minimum of 2" onto WRB surface.

g. Air seal the interior side of the rough opening gap with low-expansion foam sealant intended for window installation. Avoid gaps or voids in the air seal. A tight interior air seal of the rough opening gap will promote proper drainage and prevent drafty window installations (see Figure 5).

SPECIAL CONDITIONS & ADDITIONAL RESOURCES

- Where the FPIS material is greater than 1½" thick or less than 15 psi compressive strength, or where additional window or door support may be required (e.g., opening width > 6' or design wind load > 35 psf), it is recommended that a rough opening extension be applied to the rough opening. This can be done by use of 2x wood buck (see Figure 6) installed into the rough opening (which must be planned during rough framing) or by a "picture frame" furring (see Figure 7) installed around the perimeter of the rough opening of the same thickness as the FPIS for a flush installation (which can be installed at any time prior to window installation). In both cases, the window installation and flashing follow the same steps as indicated above. For additional installation guidance on this practice refer to: continuousinsulation.org/window-installation.
- A similar practice may be applied to integral flange door installations; however, door thresholds must be fully supported by blocking or rough opening extension as described above. In addition, where door frame or door hinges are required to be anchored to rough opening framing, ensure the FPIS thickness can be accommodated such that the anchorage fasteners (typically screws) embed into framing material with the minimum required edge distance.
- Where a separate WRB membrane layer is installed over or under the FPIS, refer to FMA/AAMA/WDMA 500-16 Standard Practice for the Installation of Mounting Flange Windows into Walls Utilizing Foam Plastic Insulating Sheathing (FPIS) with a Separate Water-Resistive Barrier (WRB) for appropriate installation and flashing details.

RECOMMENDED TOOLS AND ACCESSORIES

- Tape measure
- Level
- Hammer
- Power screw driver with clutch
- Shims
- Sealant*
- Flashing*
- Fasteners*

*Follow manufacturer's specifications and installation recommendations as applicable.

Additional Resources

- Window Installation in Walls with Foam Sheathing
- Water-Resistive Barrier
- Continuous Insulation for Residential Windows
- Continuous Insulation for Commercial Windows
- ANSI/ABTG FS 200.1 Standard, Section 3.6 (serves as basis for this Quick Guide)

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"Right-Sized" Wall Bracing & Foam Plastic Insulating Sheathing (FPIS)

INTRODUCTION

Wall bracing provides necessary structural integrity to a home or building during an extreme wind or seismic event. But, wall bracing is not a one-size-fits-all proposition. Too little wall bracing decreases the safety of the structure. On the other hand, too much wall bracing wastes resources and adds unnecessary cost. To achieve an affordable, safe, and energy efficient home, one must "right-size" wall bracing together with other important design considerations for overall value (cost and performance).

Foam plastic insulating sheathing (FPIS) is not a wall bracing material. It is, however, a multi-functional exterior wall sheathing with many benefits and capabilities including thermal performance as continuous insulation, moisture resistance, and other building science benefits. When teamed-up with a "right-sized" wall bracing approach, FPIS can be used as the sole exterior sheathing behind cladding or as "over-sheathing" placed over exterior structural sheathing or panel bracing material. In both cases, the FPIS serves to protect the wall structure against costly and damaging effects of water, vapor, and thermal bridging. (See Wall Calculators for more details.)

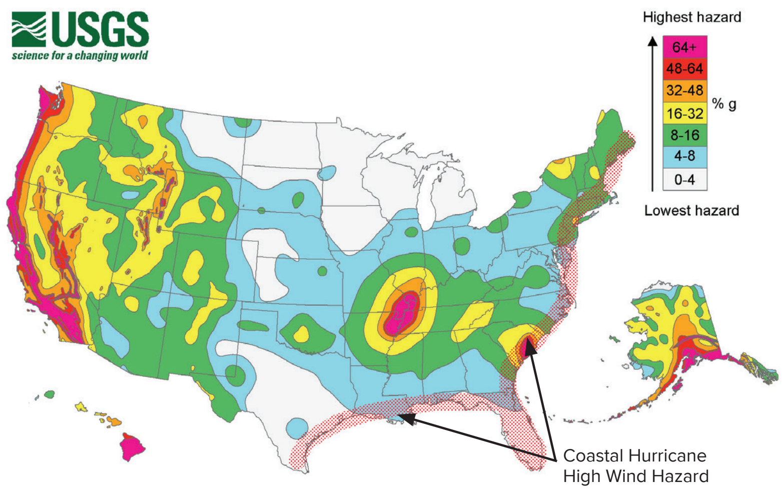


Figure 1. **Map for Wind and Earthquake Hazards in U.S.**

Source: NIST Earthquake Risk Reduction in Buildings and Infrastructure Program

In high wind and seismic hazard regions and particularly for larger custom or luxury homes, it is necessary to use stronger bracing methods with little flexibility in how to achieve acceptable wall bracing. However, in lower wind and seismic hazard regions covering most of the U.S. (see Figure 1) opportunities exist to "right-size" wall bracing to maximize overall wall value with FPIS as shown in the following case studies.[1]

CLICK FOR IRC WALL BRACING DESIGN TOOL

CASE STUDY 1: Basic Affordable Home

For a simple and affordable house plan of 1 or 1-½ stories (see Figure 2), an optimal wall construction for structural and energy performance may include:

- Gypsum wall board on the interior side of exterior walls (installed as wall bracing per code).
- Wood let-in or metal angle or X-braces applied to surface of studs (as needed per code to supplement gypsum bracing or to serve as temporary bracing during construction).
- 2x4 (R13) or 2x6 (R20) framing and cavity insulation as required by the building and energy codes.
- R5 to R10 rigid FPIS continuous insulation (ci) on the exterior side of the wall studs.
- Other components (siding, water-resistive barrier, vapor retarder, etc.) as required by code.

Figure 2. **Example plan for a basic affordable home.**

Source: IRC Wall Bracing: A Guide for Builders, Designers and Plan Reviewers

[1] These case studies are based on optimizing compliance with the International Residential Code (IRC) and the International Energy Conservation Code (IECC).

Two key benefits of the wall construction outlined in Case Study 1 are:

1. The wall bracing approach represents a traditional U.S. wall bracing practice. The value of the gypsum wall board is enhanced by installing it as wall bracing per code on the interior side of exterior walls. It can also be used for bracing of interior wall lines where required to achieve code compliance. Generally, this application only requires additional fastening beyond that required for installation as the interior finish material. Wood let-in or metal angle (X-braces) can be added for temporary bracing during construction and additional permanent bracing.
2. The use of FPIS installed on the exterior side of studs also serves multiple purposes including continuous insulation, siding backer, water-resistive barrier, air-barrier, and vapor control. Thus, it can eliminate the need for other material layers on the wall assembly to reduce cost while maintaining or enhancing required performance. FPIS also can be used to allow 2x4 wall construction instead of 2x6 wall construction for reduced framing cost and increased useable floor area while still satisfying energy code insulation requirements.

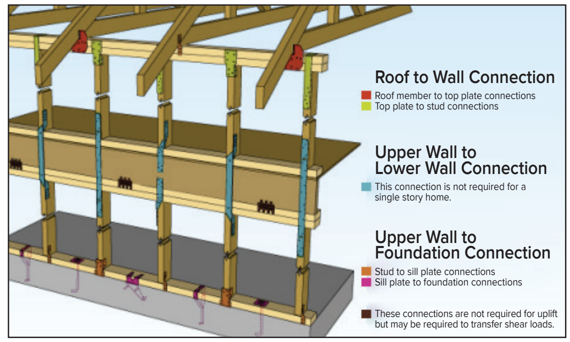


Figure 3. Continuous load path to resist wind uplift.

Source: Insurance Institute for Building & Home Safety as published in HUD Durability by Design, 2nd Edition, p. 131

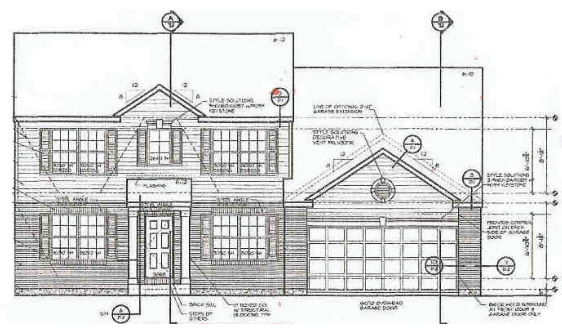
NOTE: Where required by code and as shown in Figure 3, additional framing fasteners or connection hardware may be required to provide a sufficient wind-uplift load path from the roof, through the walls, and into the foundation—a concern that applies to all homes regardless of the bracing method used or exterior sheathing materials used. Experience has shown that wind-uplift is often a more significant safety concern than wall bracing. The exterior siding, such as vinyl siding, and FPIS material should also be specified for code-required wind resistance.

CASE STUDY 2: "Move-up" (Intermediate) Home

For an optimal design on intermediate sized homes like that shown in Figure 4, one must consider a multi-faceted bracing approach to achieve a "right-sized" solution. Thus, this plan may use a combination of bracing methods and materials as follows:

1. Exterior side walls and rear walls on both stories with relatively few window and door openings—same as Case Study 1 (gypsum wall board bracing with additional let-in or metal braces as needed).
2. Street facing exterior walls with relatively large amounts of openings—use continuous wood structural panel bracing.
3. Garage opening with narrow wall segments to either side—use a "portal frame" tying the wall and header framing and structural sheathing together as a rigid unit.
4. Select interior walls—use gypsum wall board bracing on one or both sides (e.g., the shared garage and house walls typically have gypsum wall board on both sides as do many interior walls).

The key benefits of investing in this design effort include optimized performance and cost savings that are especially relevant to house plans that may be used repeatedly.



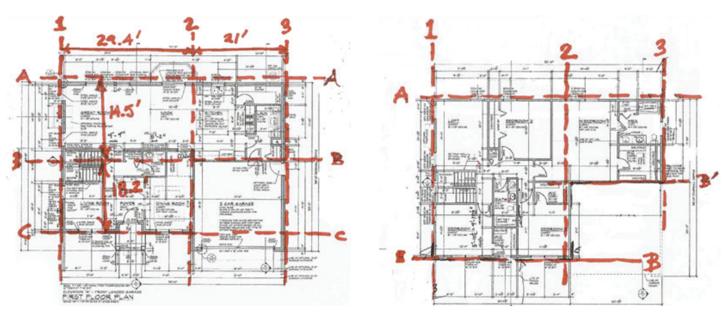


Figure 4. Example plan for a typical "move-up" home.

Source: IRC Wall Bracing: A Guide for Builders, Designers and Plan Reviewers

CONCLUSION

There are many possibilities to "right-size" wall bracing for optimal wall designs that also make use of the many benefits and capabilities of FPIS. A building designer with detailed knowledge of wall bracing provisions in Section R602 of the International Residential Code can be a valuable resource in exploring those possibilities. For more information on how to optimize wall bracing using prescriptive or engineered wall bracing, refer to this IRC Wood Wall Bracing Calculator and this guide.

QUICK GUIDE
Foam Plastic Applications for Better Building

Moisture Control for Frame Walls
Code Compliant Wall Detailing

Integration of code-compliance requirements and best practices for moisture control of frame wall assemblies (based on 2021 IRC/2024 IRC).

FIGURE KEY:
ci = continuous insulation
VR = vapor retarder
AB = air barrier
WRB = water-resistive barrier
FPIS = foam plastic insulating sheathing
EIFS = exterior insulation & finish system
ccSPF = closed-cell spray foam

Flashing (IRC Section R703.4): Flashing at siding transitions, fenestration, and other wall penetrations or details not shown; flash to the designated WRB layer (location in wall may vary) and kick-out to exterior or cladding where required at weeps, etc.

Cladding Connections (IRC Section R703.3): For connections through FPIS refer also to IRC Section R703.15.

Use codes below to access additional resources designed to help support proper implementation of the code compliance and best practice information illustrated in this guide.

Wall Calculators

FACTS Sheet Library

Quick Guide Library

Structural Sheathing

Specify and install structural sheathing per IRC Chapter 6 where used for wall bracing. Examples include OSB, plywood, gypsum sheathing, fiberboard, diagonal wood boards, etc. (Wood let-in and metal brace options not shown.)

Lap Sidings (vinyl, wood, aluminum, fiber-cement, etc.)

Specify and install lap sidings per IRC Section R703. In Climate Zones 4-8 where using a Class III interior VR, two options to control water vapor are provided in Table R702.7(3):

(1) Without exterior ci – siding must be back-vented (e.g., furred) or vented siding (e.g., vinyl).

(2) With exterior ci – siding not required to be back-vented or vented siding.

Back venting or vented siding is otherwise not required but is a recommended best practice, especially in in moist or marine climate regions.

Stucco, Adhered Masonry Veneer, Cement Panel Siding, etc.

Specify and install WRB per IRC Section R703.7.3. In Moist/Marine climate regions, a minimum 3/16" drainage space is required. See drainage space location options based on WRB location specified.*

Alternative drainage methods include drainage matt, drain wrap, or channeled back of FPIS with separate WRB on its interior side. All alternatives must have minimum 90% drainage efficiency per ASTM E2273 or E2925.

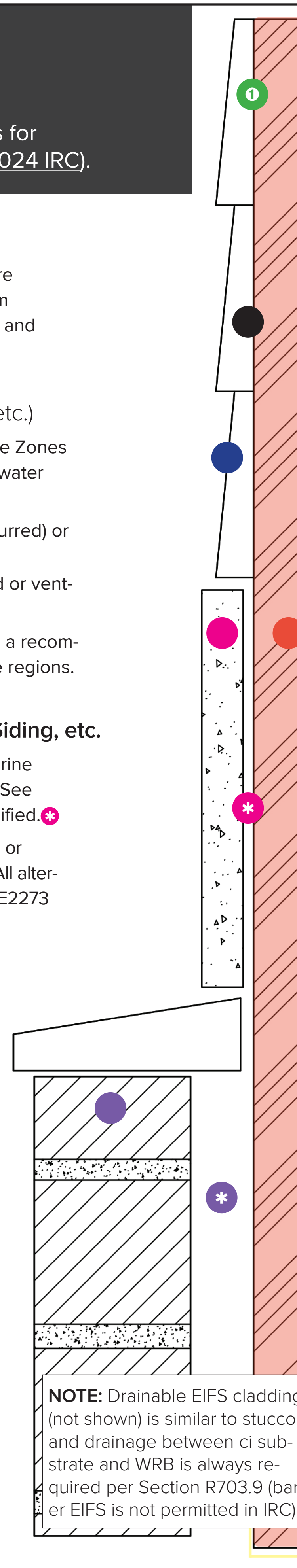
Anchored Masonry Veneer (stone & brick)

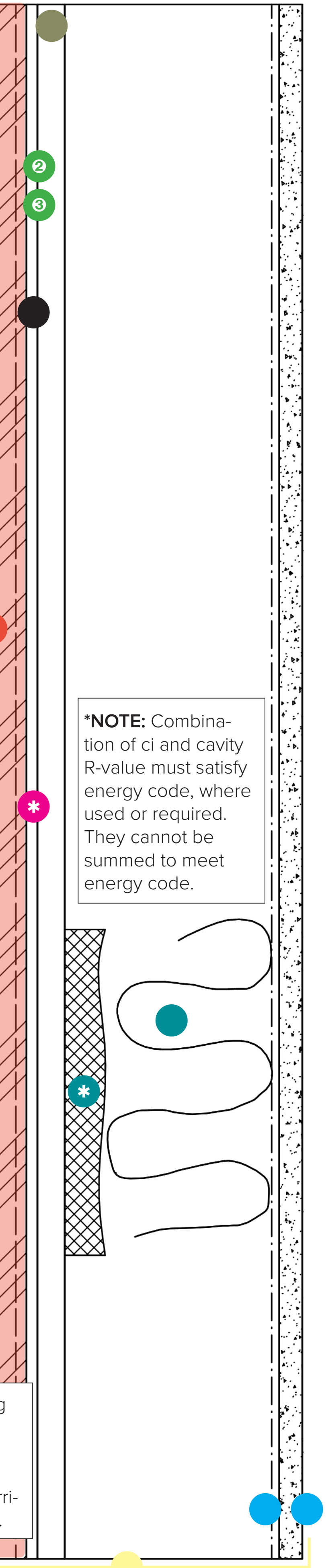
1" ventilation and draining space required for all anchored stone or brick veneer in all climate zones (see Section R703.8).*

Also qualifies as vented cladding for use of Class III VR on walls without exterior ci per Table R702.7(3).

Air Barrier (AB)

A continuous AB is used in all climate zones to achieve required whole buildilng air-change-per-hour (ACH) limits per energy code and to protect wall from moist air intrusion. The designated AB material layer must have joints, seams, gaps, intersections, and penetrations sealed. AB material can be the WRB, the ci, the structural sheathing, the ccSPF cavity insulation, the VR, or gypsum wallboard. Any material or combination thereof must meet energy code requirements for AB material properties (i.e., essentially air impermeable). Recommended best practice is to provide AB on both sides of air-permeable insulation materials (i.e., on exterior and interior sides of wall cavity) for improved thermal performance and moisture control.





Water-Resistive Barrier (WRB)

Specify and install a WRB in accordance with IRC Section R703.2. WRB material and location options include:

1. Surface of FPIS WRB System w/ taped joints - FPIS surface used as WRB
2. Separate WRB behind ci - Any ci insulation type not used as WRB
3. Membrane (wrap), spray-applied, or WRB wall sheathing

Drainage Space (location based on WRB option used)

Where required, located between cladding and WRB (see above). See requirements for reservoir cladding types (brick, stucco, adhered veneer, etc.).*

Where not required, use as recommended best practice.

Continuous Insulation (ci)*

Where used or required for energy code compliance, ci R-value must meet IRC Table R702.7(2) and Table R702.7(3), (4), or (5) as applicable based on Climate Zone and the interior VR Class specified. The required minimum ci R-values ensure adequate temperature control to prevent condensation and moisture accumulation within the wall. Increasing ci R-values above code-minimums will further improve thermal performance and moisture control.

Where non-vapor permeable (< 5 perm) ci is used (e.g., FPIS), it will mitigate inward vapor drive from reservoir claddings (e.g., stucco, adhered veneer, brick, etc.). For similar reasons, it is recommended to use a moderate to low perm WRB (e.g., < 20 perm) behind a vapor permeable ci material.

Cavity Insulation*

If ccSPF is used at thickness to achieve 1.5 perms or less, the R-value can be combined with ci R-value to meet ci requirements of Tables R702.7(3), (4), or (5) to decrease the exterior ci thickness/R-value required, but ccSPF must still be treated as cavity insulation for energy code compliance. *

Interior Vapor Retarder (VR)[1,2]

Use of a Class I interior VR (that is not "smart") in frame walls with a Class I exterior VR is not permitted without an approved design. Double vapor "barriers" should be avoided.

An interior vapor retarder is not required in Climate Zones 1, 2, and 3. Responsive ("smart") Class I or II VRs are allowed on interior side of any frame wall in all Climate Zones.

If ci used or required: Specify VR per Table R702.7(2) in coordination with ci and cavity insulation R-values per Tables R702.7(3), (4), or (5) as applicable. Class I/II VR must be a responsive ("smart") VR if ci is FPIS (e.g., non-vapor permeable), otherwise use Class III VR.

If ci not used: Specify VR per Table R702.7(2) with best practice recommendation to specify Class I responsive ("smart") VR in Climate Zones 5-8 and install as an air barrier. Use of a Class III VR without ci is not recommended even though permitted.

NOTES ON VAPOR RETARDER CLASSES AND RESPONSIVE VAPOR RETARDERS:

1. Vapor retarder classes are defined in Table R702.2(1) and include Class I (e.g., poly), Class II (e.g., coated kraft paper facer), and Class III (e.g., vapor retarder latex paint per manufacturer's instructions). Class I has vapor permeance of 0.1 of less, Class II is 0.1 to 1 perms, and Class III is 1 to 10 perms.
2. A responsive or "smart" vapor retarder is Class I or II (i.e., 1 perm or less) that becomes more vapor open in a humid environment such that drying occurs when needed. Regular vapor retarders are classified on the basis of "dry cup" vapor permeance measurements at low humidity conditions. Responsive vapor retarders are additionally required to have a permeance of greater than 1 perm when measured by the "wet cup" method of ASTM E96 at a moderately high humidity condition. Coated kraft paper facer is a Class II responsive vapor retarder. Class I responsive vapor retarders are typically proprietary films or membrane products.

Contact us.

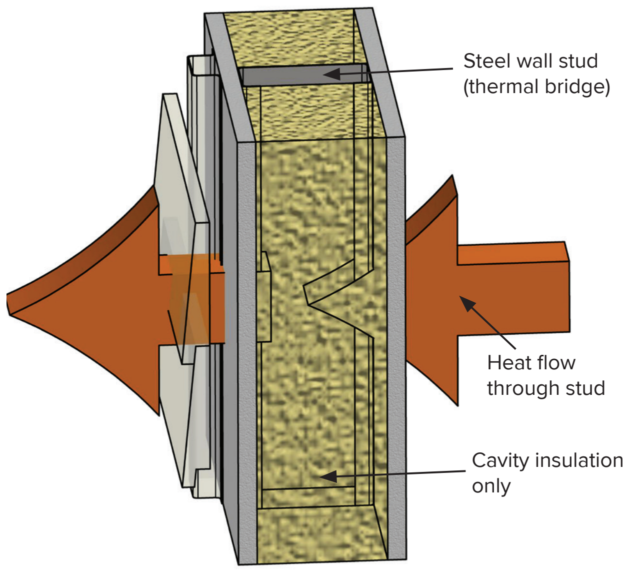
Owned and operated by the Applied Building Technology Group with support from the Foam Sheathing Committee (FSC) of the American Chemistry Council, **continuousinsulation.org** provides informational resources intended to assist the foam plastic insulating sheathing industry, using sound science to develop research supporting the reliable, efficient, and economic design and installation of foam sheathing.

CLADDING CONNECTIONS to Steel Frame Walls with Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

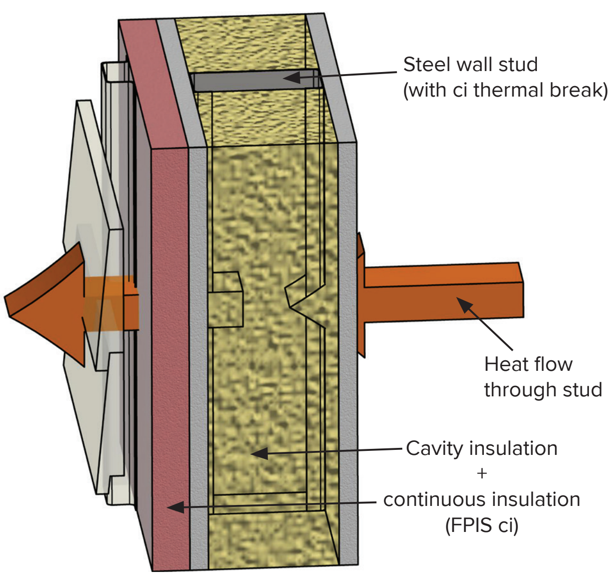
QUICK GUIDE
Foam Plastic Applications for Better Building

STEP 1: COMPLY WITH ENERGY CODE CONTINUOUS INSULATION REQUIREMENTS

Continuous insulation (ci) is typically required for cold-formed steel frame walls to comply with modern energy codes (see steel frame wall calculator) and to prevent thermal bridging caused by steel framing as shown in Figure 1. In addition to meeting ci R-value requirements, cladding connections through ci must comply with the energy code's definition of ci (see below) and the building code's requirements for cladding attachment (see Step 2).



Thermal bridging in steel framed wall with cavity insulation only.

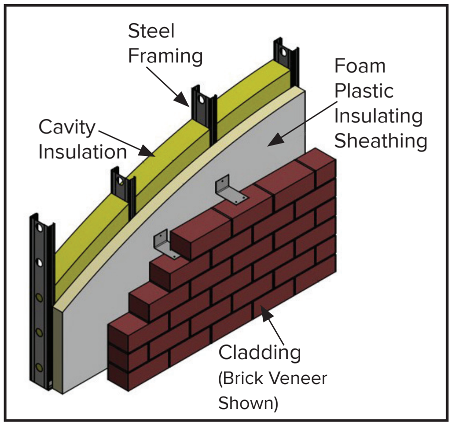


Thermal bridging in steel framed wall with cavity insulation and foam plastic insulating sheathing (FPIS) continuous insulation (ci).

Figure 1. Illustration of FPIS ci used to minimize thermal bridging through steel framing.

Continuous insulation (ci) is defined in the International Energy Conservation Code (IECC) and ASHRAE 90.1 Standard as "insulation that is uncompressed and continuous across all structural members without thermal bridges other than fasteners and service openings."

A key part of the code's definition for ci requires that only fasteners (e.g., nails or screws) penetrate the ci to minimize thermal bridging. This is particularly important for detailing cladding installations, like those shown in Figure 2, such that the prescriptive R-values for ci can be used as a simple means of energy code compliance. Cladding and furring attachments that result in more than just fasteners penetrating the ci, such as metal z-girts or furring support brackets, cannot use the prescriptive ci R-values for compliance. Instead, the total wall assembly's U-factor must be determined by calculation or testing and it must include the impact of thermal bridging of the cladding support system. Therefore, use of only fasteners to attach cladding or furring through FPIS ci is necessary to easily comply with the energy code. Adhesive attachment methods also comply.



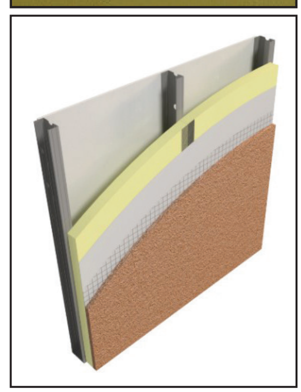


Figure 2. Three examples of cladding and FPIS ci installation on steel frame wall assemblies to mitigate thermal bridging and comply with the ci definition.

Another key part of the ci definition requires that the insulation be uncompressed. Because FPIS ci is a rigid foam plastic with relatively high compressive strength, it is possible to fasten cladding and furring to steel framing or other wall substrates without compressing the insulation. This avoids reduced thermal performance due to insulation compression at points of connection, improves constructability, and makes it possible to fully comply with the ci definition.

STEP 2: COMPLY WITH BUILDING CODE REQUIREMENTS FOR CLADDING CONNECTIONS

Recent editions of the International Building Code (IBC), Chapter 26 (2021 or earlier) or Chapter 14 (2024), and the International Residential Code (IRC), Section R703, include three options for attachment of claddings through a layer of FPIS ci using properly specified fasteners that comply with the energy code's ci definition:

1. Direct Cladding Attachment through FPIS ci (see Figure 3A and Table 1)
2. Furring Attachment through FPIS ci (see Figure 3B and 3C and Table 2)
3. Cladding Attachment through FPIS ci to a Wood Structural Panel Substrate (see Figure 4 and Table 3)

These procedures provide assurance that the fastening schedule is sufficient to support the cladding weight and resist movement once installed over FPIS ci (up to 4-inches thick) depending on various conditions, such as cladding weight (see text box). The cladding manufacturer and building code's attachment requirements should be consulted for additional installation requirements, especially where a more stringent fastening schedule is required for reasons other than support of the cladding weight. Also, important specifications and limitations in the table footnotes should be carefully considered. Finally, it is important to note that these solutions are not exhaustive and that other commodity or proprietary fastener solutions or details may be available by design or through the cladding, fastener, or FPIS manufacturer.

Typical cladding materials included in the weight classes listed in Tables 1, 2, and 3 are as follows (verify with cladding manufacturer data):[1]

- 3 psf – e.g., wood lap and panel siding, vinyl siding, and most fiber-cement sidings
- 11 psf – e.g., 3-coat Portland cement stucco
- 18 psf – e.g., medium weight adhered stone veneer
- 25 psf – e.g., heavy weight adhered stone veneer

[1] The attachment requirements of Tables 1, 2, and 3 do not apply to separately supported claddings such as anchored masonry veneer (i.e., conventional brick or stone veneer). Brick ties and their fasteners are intended to resist out-of-plane wind and seismic loads and not support the veneer weight. Thermally efficient brick ties and fasteners may be specified such that they meet the intent of the ci definition for energy code compliance.

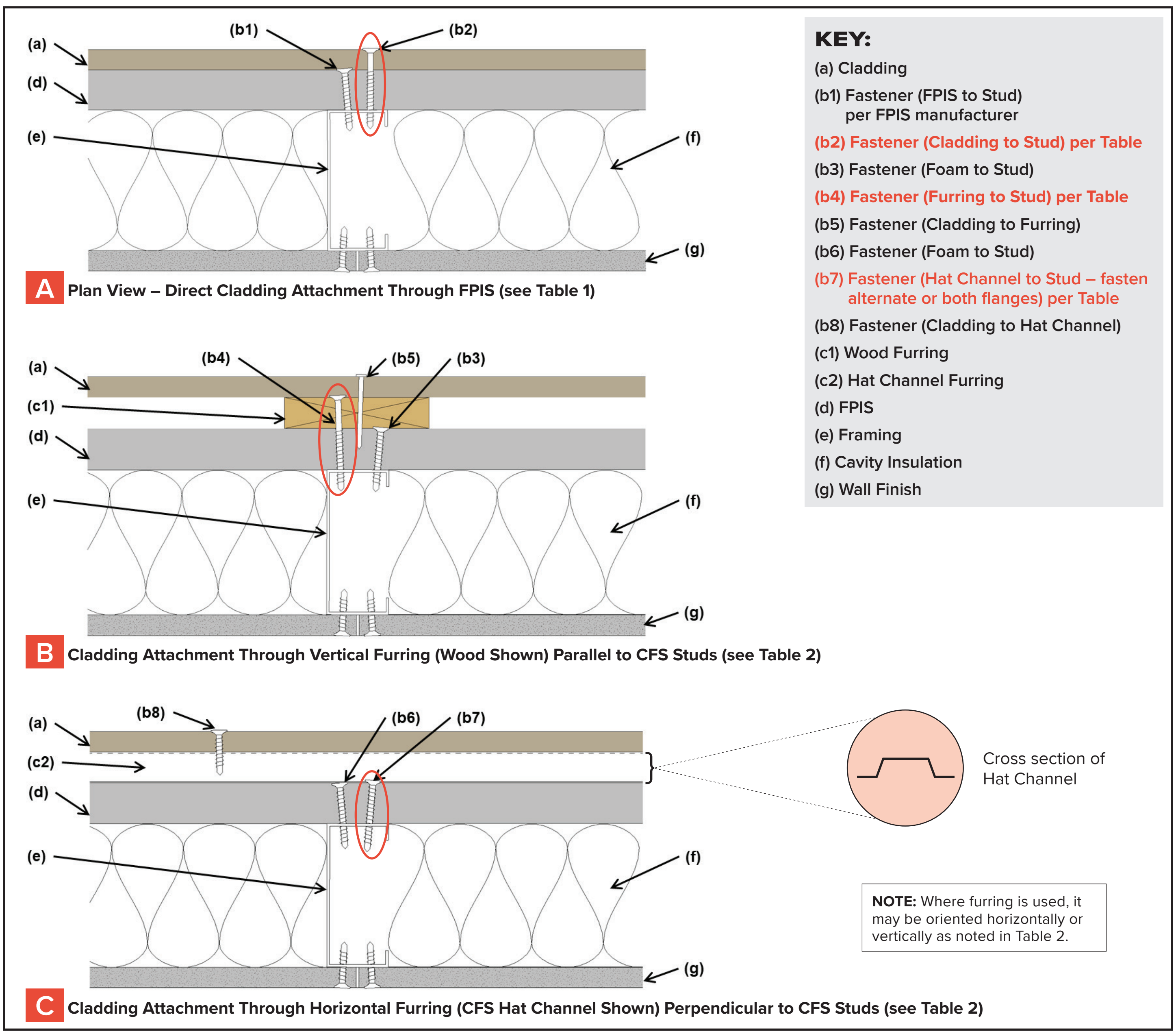


Figure 3. Illustration of cladding and furring attachments through FPIS to cold-formed steel (CFS) framing.

Table 1. Siding Minimum Fastening Requirements to Cold-formed Steel Framing for Direct Cladding Attachment Over FPIS to Support Cladding System Weight [1,2,3,4]

CLADDING FASTENER THROUGH FPIS INTO:	Siding Fastener Type & Minimum Size	Siding Fastener Vertical Spacing (in.)	MAXIMUM THICKNESS OF FPIS (IN.)							
			16" o.c. Fastener Horizontal Spacing				24" o.c. Fastener Horizontal Spacing			
			CLADDING SYSTEM WEIGHT				CLADDING SYSTEM WEIGHT			
			3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Steel Framing (minimum penetration of steel thickness + 3 threads)	#8 screw (0.285" head) into 33 mil steel or thicker	6	3.00	2.95	2.20	1.45	3.00	2.35	1.25	DR
		8	3.00	2.55	1.60	0.60	3.00	1.80	DR	DR
		12	3.00	1.80	DR	DR	3.00	0.65	DR	DR
	#10 screw (0.333" head) into 33 mil steel	6	4.00	3.50	2.70	1.95	4.00	2.90	1.70	0.55
		8	4.00	3.10	2.05	1.00	4.00	2.25	0.70	DR
		12	4.00	2.25	0.70	DR	3.70	1.05	DR	DR
	#10 screw (0.333" head) into 43 mil steel or thicker	6	4.00	4.00	4.00	3.60	4.00	4.00	3.45	2.70
		8	4.00	4.00	3.70	3.00	4.00	3.85	2.80	1.80
		12	4.00	3.85	2.80	1.80	4.00	3.05	1.50	DR

For SI: 1" = 25.4 mm; 1 pound per square foot [psf] = 0.0479 kPa

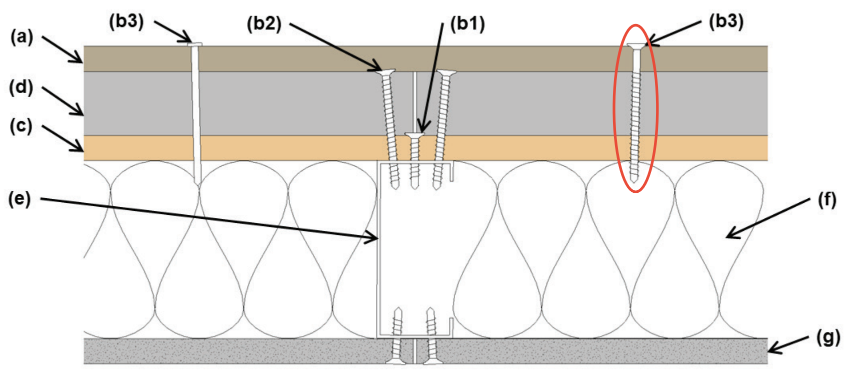
1. Tabulated values are based on minimum 33 ksi steel for 33 mil and 43 mil steel and 50 ksi steel for 54 mil steel or thicker.
2. Screws shall comply with the requirements of AISI S240.
3. FPIS shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.
4. DR = Design Required

Table 2. Furring Minimum Fastening Requirements to Cold-formed Steel Framing for Application Over FPIS to Support Cladding System Weight [1,2,3,4,5]

FURRING MATERIAL	Framing Member	Fastener Type & Min. Size	Minimum Penetration into Wall Framing (in.)	Fastener Spacing in Furring (in.)	MAXIMUM THICKNESS OF FPIS (IN.)							
					16" o.c. Furring				24" o.c. Furring			
					CLADDING SYSTEM WEIGHT				CLADDING SYSTEM WEIGHT			
					3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Minimum 33mil Steel Furring or Minimum 1x3 Wood Furring	33 mil Cold-formed Steel Stud	#8 screw (0.285" head)	Steel thickness +3 threads	12	3.00	1.80	DR	DR	3.00	0.65	DR	DR
				16	3.00	1.00	DR	DR	2.85	DR	DR	DR
				24	2.85	DR	DR	DR	2.20	DR	DR	DR
		#10 screw (0.333" head)	Steel thickness +3 threads	12	4.00	2.25	0.70	DR	3.70	1.05	DR	DR
				16	3.85	1.45	DR	DR	3.40	DR	DR	DR
				24	3.40	DR	DR	DR	2.70	DR	DR	DR
	43 mil or thicker Cold-formed Steel Stud	#8 screw (0.285" head)	Steel thickness +3 threads	12	3.00	1.80	DR	DR	3.00	0.65	DR	DR
				16	3.00	1.00	DR	DR	2.85	DR	DR	DR
				24	2.85	DR	DR	DR	2.20	DR	DR	DR
		#10 screw (0.333" head)	Steel thickness +3 threads	12	4.00	3.85	2.80	1.80	4.00	3.05	1.50	DR
				16	4.00	3.30	1.95	0.60	4.00	2.25	DR	DR
				24	4.00	2.25	DR	DR	4.00	0.65	DR	DR

For SI: 1" = 25.4 mm; 1 pound per square foot [psf] = 0.0479 kPa

1. Table values are based on wood furring of Spruce-Pine-Fir or any softwood species with a specific gravity of 0.42 or greater per NDS. Steel furring shall be minimum 33 ksi steel. Cold-formed steel studs shall be minimum 33 ksi steel for 33 mil and 43 mil thickness and 50 ksi steel for 54 mil thickness.
2. Screws shall comply with the requirements of AISI S240.
3. Where the required cladding fastener penetration into wood material exceeds ¾" inches and is not more than 1-½", a minimum 2-inch nominal wood furring or an approved cladding attachment design shall be used.
4. Furring shall be spaced a maximum of 24" o.c. in a vertical or horizontal orientation.
   a. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing.
   b. In a horizontal orientation, furring shall fastened at each stud with a number of fasteners equivalent to that required by the fastener spacing. If the required fastener spacing is 12" o.c. and the studs are 24" o.c., then two (2) fasteners would be required at each stud (24/12=2). In no case shall fasteners be spaced more than 24" (0.6 m) apart.
5. FPIS shall have a minimum compressive strength of 15 psi, in accordance with ASTM C578 or ASTM C1289.
6. DR = Design Required



KEY:

(a) Cladding

(b1) Fastener (WSP to Stud) per code

(b2) Fastener (FPIS to Stud or WSP) per FPIS manufacturer

(b3) Fastener (Cladding to WSP – nail or screw) per Table 3

(c) WSP

(d) FPIS

(e) Framing

(f) Cavity Insulation

(g) Wall Finish

Figure 4. Illustration of light-weight cladding (≤3 psf) attachment through maximum 2"-thick FPIS to minimum 7/16"-thick wood structural panel (WSP) sheathing.

Table 3. Light-weight Cladding (≤3 psf) Minimum Fastening Requirements for Attachment Through Maximum 2"-thick FPIS to Minimum 7/16"-thick Wood Structural Panel [1,2,3]

TYPE AND SIZE OF FASTENER	HORIZONTAL SPACING OF FASTENERS ALONG SIDING
Roof sheathing ring shank nail (0.120" min. shank; 0.281" head)	12" oc
Post frame ring shank nail (0.148" min. shank; 5/16" head)	15" oc
No. 6 screw (0.138" min. shank; 0.262" head)	12" oc
No. 8 screw (0.164" min. shank; 0.312" head)	16" oc

For SI: 1" = 25.4 mm

1. Horizontal spacing of fasteners along siding is based on a siding width (distance between horizontal rows of fasteners) of 12". For other siding widths, multiply required horizontal spacing by 12/w where w is the siding width in inches.
2. This table is based on IRC Table R703.3.3. Use of this table is limited to the wind load scope limits for cladding attachments in accordance with Section R703.3.2 of the IRC (i.e., maximum 30 psf negative design wind pressure).
3. The cladding fastener must be of sufficient length to penetrate a minimum of ¼" beyond the back side of the wood structural panel sheathing.

Additional Resources

For a more in-depth treatment of this subject including installation, code-compliance examples, design methodology, applications other than cladding connections, and supporting research, refer to:

- **ContinuousInsulation.org:** Attachment of Exterior Wall Coverings through FPIS
- **ABTG Research Report 1503-02:** Attachment of Exterior Wall Coverings Through Foam Plastic Insulating Sheathing (FPIS) to Wood or Steel Wall Framing

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QUICK GUIDE

Foam Plastic Applications for Better Building

CODE-COMPLIANT VINYL SIDING APPLICATIONS over Foam Plastic Insulating Sheathing (FPIS) Continuous Insulation (ci)

IMPORTANT! READ ALL INSTRUCTIONS BEFORE BEGINNING INSTALLATION

INTRODUCTION

Vinyl siding is a popular siding material and is commonly applied over foam plastic insulating sheathing (FPIS) continuous insulation (ci) used for building code and energy code compliant walls. Like other siding products, it must be specified and installed to resist design wind load pressures as required by code. Design wind load pressure ratings of standard vinyl siding products rely on ASTM D3679.[1] This standard uniquely incorporates wind pressure equalization effects that account for reduced wind load on the siding material. This load-reducing effect varies depending on construction of the wall assembly to which the vinyl siding is installed.

This Quick Guide outlines a step-by-step process to ensure vinyl siding is properly specified and installed when applied over FPIS ci for a durable and code-compliant installation.

STEP 1: VERIFY MATERIAL COMPLIANCE.

Ensure that the specified vinyl siding product complies with ASTM D3679 in accordance with 2024 IRC Section R703.11 and identify the product's design wind load pressure rating as required for any vinyl siding application (see Photo 1).

Photo courtesy of the Vinyl Siding Institute.

Photo 1. Example of typical vinyl siding product label with a design wind load pressure rating of 77.2 psf.

STEP 2: CONSIDER ADDITIONAL REQUIREMENTS FOR INSTALLATION OVER FPIS.

Determine if any additional specification and installation requirements are applicable for vinyl siding installed over FPIS in accordance with 2024 IRC Section R703.11.2, including the listed exceptions as noted in the table below. The following three installation conditions govern the design wind pressure rating and installation of the vinyl siding and the FPIS material:

CONDITION 1	CONDITION 2	CONDITION 3
2024 IRC Section R703.11.2, Exception 1	2024 IRC Section R703.11.2	2024 IRC Section R703.11.2, Exception 2
FPIS installed as "Over-sheathing" (see Figure 1)	**FPIS installed directly over Open Stud Cavities (see Figure 2)** **OPTION A:** FPIS material and siding fastened as an assembly to resist wind load **OPTION B:** FPIS material fastened to resist design wind load independent of siding	**Vinyl siding installed over FPIS in accordance with siding manufacturer's installation instructions**

[1] ASTM D3679 is referenced in Section R703.11 of the 2021 IRC and applies to standard "hollow-backed" vinyl siding. However, the guidance in this Quick Guide can be applied equivalently to insulated vinyl siding products complying with ASTM D7793 as addressed in 2021 IRC Section R703.13.

CONDITION 1:
FPIS INSTALLED AS "OVER-SHEATHING"

(2024 IRC Section R703.11.2, Exception 1)

As shown in Figure 1, this condition applies where the FPIS is "applied directly over wood structural panels, fiberboard, gypsum sheathing, or other approved backing capable of independently resisting the design wind pressure." In this condition, 2024 IRC Section R303.8 (or Section R316.8 in earlier editions) do not require that the FPIS be rated for wind pressure resistance. For the vinyl siding, simply install it over the FPIS in accordance with 2024 IRC Sections R703.3.3 (if used) and R703.11.1 and the siding manufacturer's installation instructions after verifying the following two items as required for any vinyl siding installation:

1. The length of the siding nail is sufficient to accommodate the FPIS thickness and maintain the minimum required fastener embedment in wood framing materials.
2. The design wind pressure rating of the siding (see Step 1) must meet or exceed the design wind pressure required by 2024 IRC Tables R301.2.1(1) and R301.2.1(2) based on the basic design wind speed mapped in Figure R301.2(2). For many applications within the scope of the IRC, a design wind load pressure rating of 30 psf or greater should prove to be code-compliant. Higher design pressure ratings will provide improved performance and are required in the more extreme wind exposures and regions of the U.S.

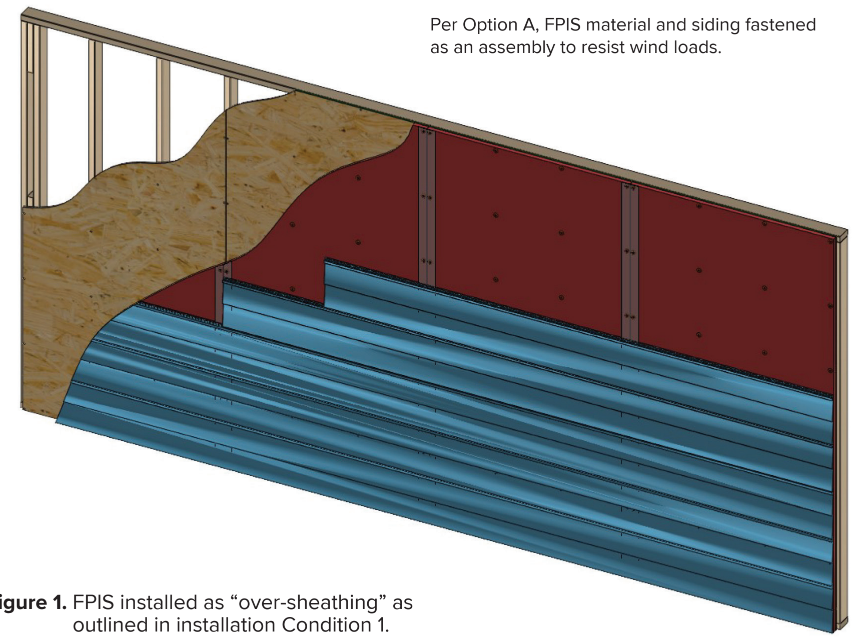

Figure 1. FPIS installed as "over-sheathing" as outlined in installation Condition 1.

CONDITION 2:
FPIS INSTALLED DIRECTLY OVER OPEN STUD CAVITIES

(2024 IRC Section R703.11.2)

For this condition, FPIS is installed directly to studs and over open stud cavities. No separate structural sheathing or solid backing is used in this assembly. There are two options related to how the FPIS layer is specified and fastened to the framing over open stud cavities as shown in Figures 2 and 3. In both options discussed below, the FPIS material itself must be rated for wind pressure resistance in accordance with 2024 IRC Section R303.8 (or Section R316.8 in earlier editions) and the ANSI/ABTG FS 100 Standard. Additionally, Option A also requires wind pressure resistance rating of the FPIS and vinyl siding as an assembly.

Option A: Vinyl siding and FPIS installed as an exterior wall covering assembly per Figure 2

(2024 IRC Section R703.11.2)

In this case, an FPIS product is secured directly to studs using a typical construction fastening schedule in accordance with the FPIS manufacturer's instructions (e.g., typically plastic cap nails at 12"oc on edges and 16"oc in the field). The vinyl siding is then secured over and fastened through the FPIS to framing members to provide permanent securement and wind load resistance as a wall covering assembly in accordance with 2024 IRC Section R703.11.2.

Because the vinyl siding attachment also supplements the FPIS attachment for wind load resistance as a wall covering assembly, the vinyl siding's required wind pressure rating is generally adjusted to be more stringent than that required for Condition 1 (above) or Condition 2, Option B (below). The more stringent design wind load pressure rating requirements for vinyl siding are found in 2024 IRC Section R703.11.2 (see Table 1 below).

Simply verify that the design wind load pressure rating for the specified vinyl siding product (as identified in Step 1) meets or exceeds the minimum tabulated rating in Table 1. Once verified, install the siding over the FPIS in accordance with the siding manufacturer's installation instructions with fasteners of sufficient length to accommodate the FPIS thickness and maintain the required fastener embedment in framing materials.

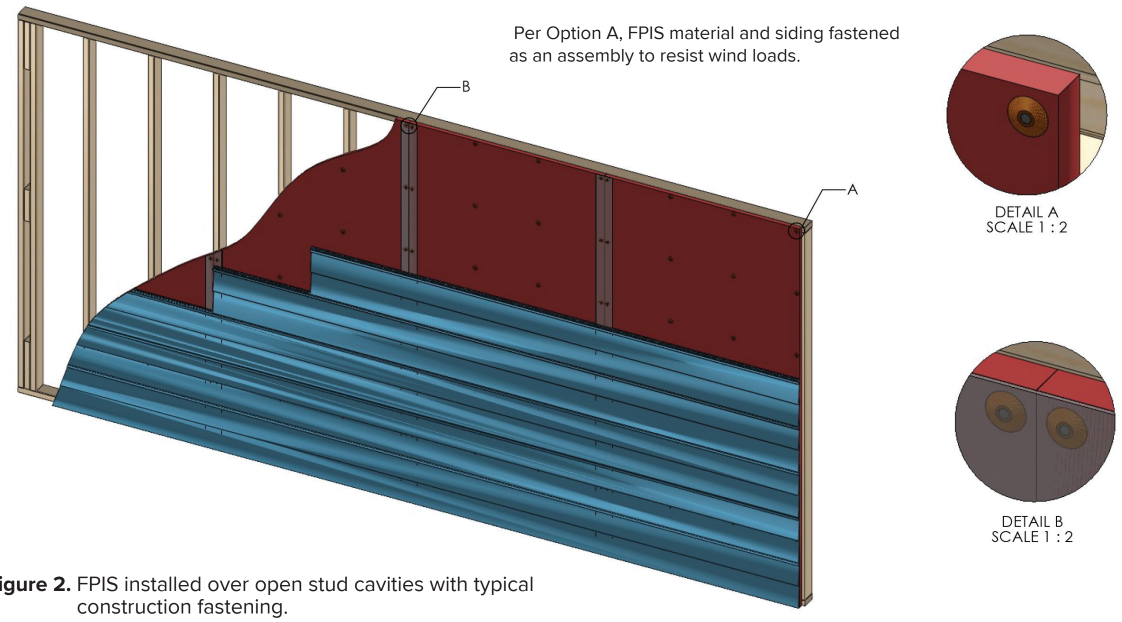

Figure 2. FPIS installed over open stud cavities with typical construction fastening.

Table 1. Required Minimum Wind Load Design Pressure Rating for Vinyl Siding Installed Over Foam Plastic Sheathing Alone *(based on IRC Table R703.11.2)* — Applies to Condition 2, Option A Only

ULTIMATE DESIGN WIND SPEED (MPH)	ADJUSTED MINIMUM DESIGN WIND PRESSURE (ASD) (PSF)[a,b]					
	Case 1: With interior gypsum wallboard[c]			Case 2: Without interior gypsum wallboard[c]		
	Exposure			Exposure		
	B	C	D	B	C	D
≤ 95	-30.0	-33.2	-39.4	-33.9	-47.4	-56.2
100	-30.0	-36.8	-43.6	-37.2	-52.5	-62.2
105	-30.0	-40.5	-48.1	-41.4	-57.9	-68.6
110	-31.8	-44.5	-52.8	-45.4	-63.5	-75.3
115	-35.5	-49.7	-59.0	-50.7	-71.0	-84.2
120	-37.4	-52.4	-62.1	-53.4	-74.8	-88.6
130	-44.9	-62.8	-74.5	-64.1	-89.7	-106
> 130	See Note d					

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa

a. Linear interpolation is permitted.

b. The table values are based on a maximum 30-foot mean roof height, and effective wind area of 10 square feet Wall Zone 5 (corner), and the ASD design component and cladding wind pressure from Table R301.2.1(1), adjusted for exposure in accordance with Table R301.2.1(2), multiplied by the following adjustment factors: 1.87 (Case 1) and 2.67 (Case 2).

c. Gypsum wallboard, gypsum panel product or equivalent.

d. For the indicated wind speed condition and where foam sheathing is the only sheathing on the exterior of a frame wall with vinyl siding, the wall assembly shall be capable of resisting an impact without puncture at least equivalent to that of a wood frame wall with minimum 7/16-inch OSB sheathing as tested in accordance with ASTM E1886. The vinyl siding shall comply with an adjusted design wind pressure requirement in accordance with Note b, using an adjustment factor of 2.67.

NOTE: The required minimum wind load design pressure rating in Table 1 depends on whether or not interior gypsum wall board is present. The interior gypsum wall board and the layers of the exterior wall covering assembly each resist a portion of the total wind load pressure acting on the overall wall assembly. When the interior gypsum wall board is not present, the portion of the total wind loading on the exterior wall covering layers increases as shown in the Table. For more information, refer to commentary in ASCE 7 Section C30.1.5 and discussion on pressure equalization in the appendix of ASTM D3679.

Option B: FPIS material *and* its fastening are capable of resisting full design wind pressure per Figure 3

(2024 IRC Section R703.11.2, Exception 3)

In this option the FPIS material *and* its fastening are specified to resist the full or total design wind load pressure acting on the wall assembly, just as required for other structural sheathing materials. For the vinyl siding, simply install it over the FPIS in accordance with 2024 IRC Section R703.11.1 and the siding manufacturer's installation instructions. Then verify the vinyl siding's wind pressure rating as required in Condition 1 where FPIS is installed as "over-sheathing." Also verify that the siding fasteners are long enough to accommodate the FPIS thickness and maintain the minimum required embedment in framing materials.

The design wind pressure rating and fastening schedule for the FPIS product must resist the code-required design wind pressure (see 2024 IRC Tables R301.2.1(1) and R301.2.1(2) and Figure R301.2(2)). The design wind pressure rating of the FPIS material and its fastening schedule for the intended wall stud spacing (e.g., 16" oc or 24" oc) must comply with 2024 IRC Section R303.8 (or Section R316.8 in earlier editions) and the ANSI/ABTG FS100 Standard. This code compliance and installation information should be obtained from the FPIS manufacturer.

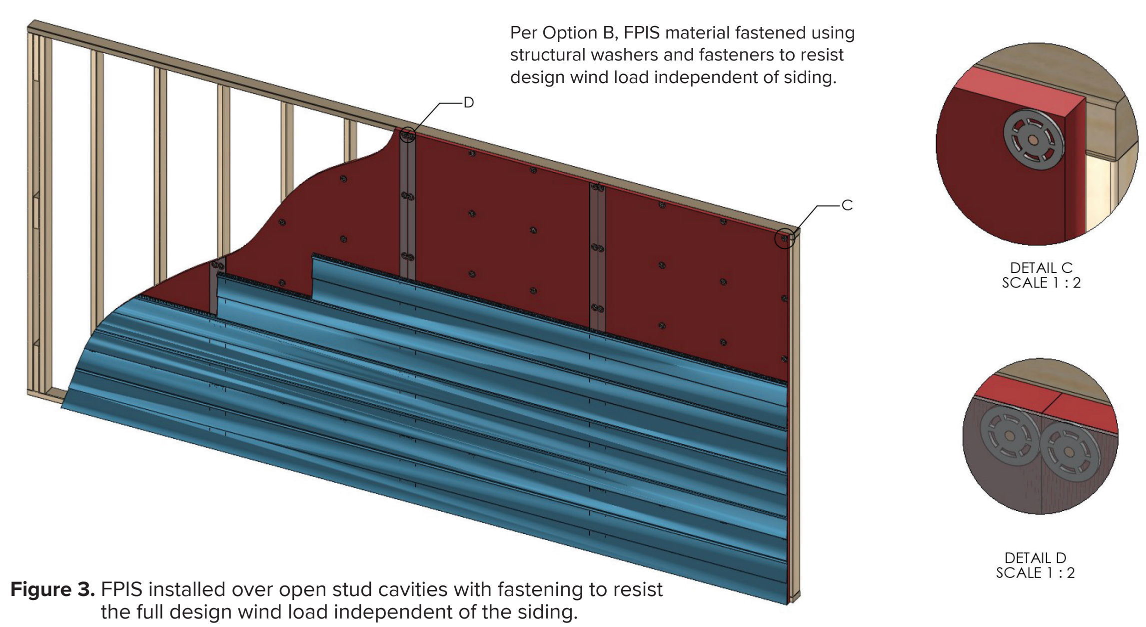

Figure 3. FPIS installed over open stud cavities with fastening to resist the full design wind load independent of the siding.

CONDITION 3:
VINYL SIDING INSTALLED OVER FPIS IN ACCORDANCE WITH THE SIDING MANUFACTURER'S INSTALLATION INSTRUCTIONS

(2024 IRC Section R703.11.2, Exception 2)

Where vinyl siding manufacturer installation instructions address a specific condition for installation over FPIS, these instructions and the applicable wind load pressure rating shall be used to demonstrate compliance.

STEP 3: VERIFY INSTALLATION IN THE FIELD.

Based on the installation condition and option chosen and the applicable code-compliance requirements determined in Steps 1 and 2 above, verify that the specified vinyl siding material, FPIS material, and their attachment schedules are correctly implemented in the field.

As a minimum recommended practice, conduct an inspection at the beginning of the FPIS and siding installations to ensure the overall wall covering assembly installation is compliant with the code.

You are well on your way to a code-compliant, durable, and high-performance wall covering as shown in Photo 2.

Photo 2. Code-compliant installations of vinyl siding over FPIS ci.

TIP: For additional information and guidance on code-compliant use of FPIS as a water-resistive barrier system, as a means to control water vapor, meet or exceed energy code requirements, and more, go to **continuousinsulation.org**.

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QUICK GUIDE
Foam Plastic Applications for Better Building

Foundation Insulation Fundamentals: Basements, Crawlspaces & Slabs with Foam Plastic Insulating Sheathing (FPIS)

IMPORTANT! READ ALL INSTRUCTIONS BEFORE BEGINNING INSTALLATION

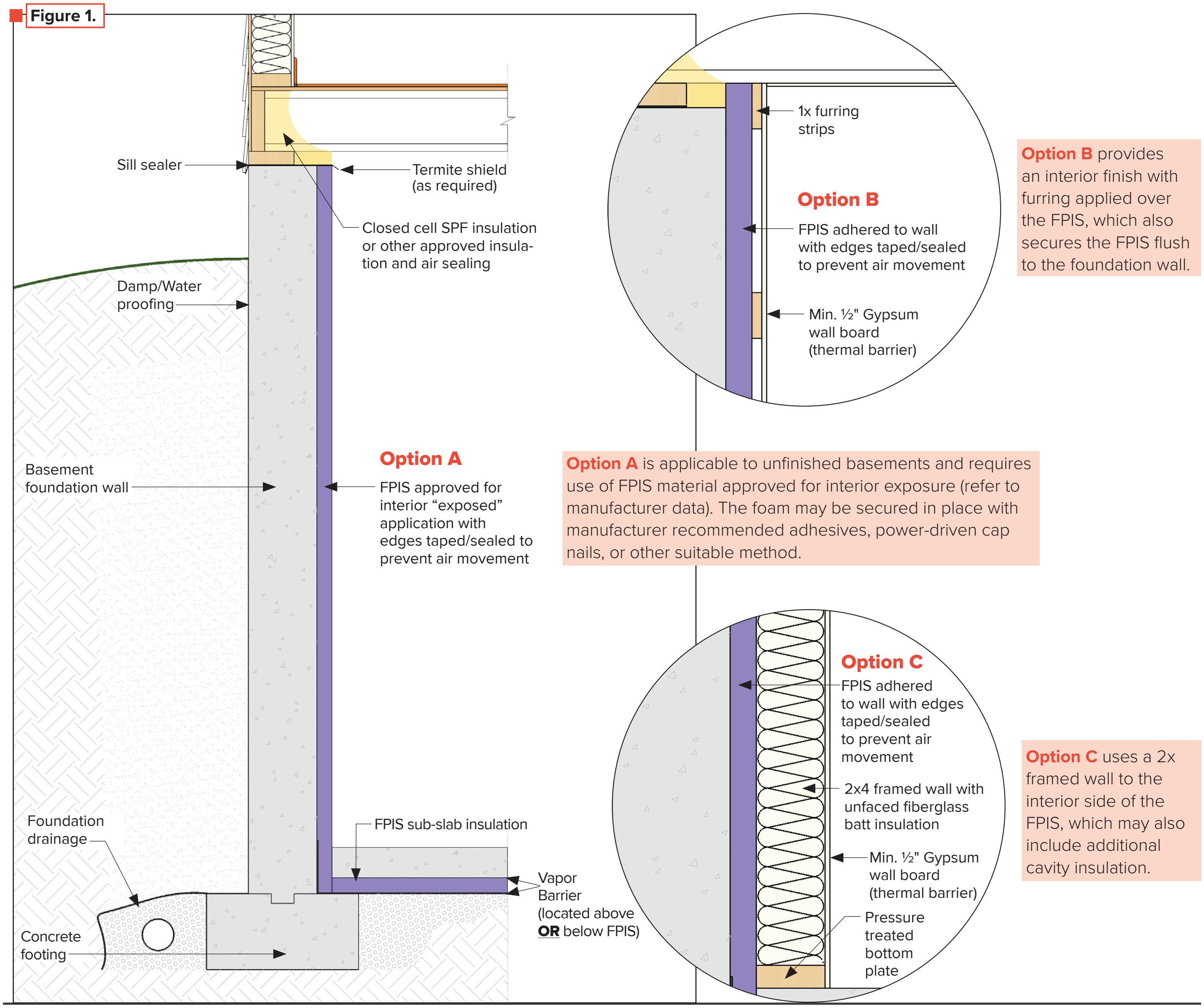
Insulating foundations can be completed in many ways. However, doing it right requires paying attention to a few key details to maximize the value of the foundation and its insulation. In addition to saving energy and increasing comfort, foundation insulation helps mitigate moisture problems and can even be used to raise the frost depth, saving thousands of dollars in foundation construction. This guide is intended to get you started by introducing some best practices for insulating foundations with foam plastic insulating sheathing (FPIS) properly installed as continuous insulation (ci). Resources are provided for further information and to support implementation.

Minimum insulation amounts will vary based on your locally adopted energy code and may be exceeded for improved performance. FPIS of ¾" to 2" in thickness is most common with R-values ranging from R4 to R12, depending on the type of FPIS material. For a high-performance home or commercial building foundation, and especially in cold climates, FPIS R-values of R-15 or more (~3" thick or greater) is not uncommon.

BASEMENT WALLS

Basement walls may be insulated on the exterior, interior, or both. However, the most common method for new and retrofit construction is to insulate on the interior side as shown in Figure 1. For basement retrofits, the basement wall insulation may be terminated at the slab surface.

Figure 1.



Some Key Points:

- In all of these details, no vapor retarder is applied to the interior side of the assembly because the FPIS serves as the thermal, vapor, and air control layers. This allows for drying to the interior as a best practice for foundation walls. Consult with a design professional as needed.
- FPIS joints should be taped for best performance.
- The sill and band joist should be air-sealed and insulated with closed-cell spray foam (as shown) or with equivalent methods.
- More detailed information and additional examples can be found in this Quick Guide on basement wall retrofits for use when remodeling or upgrading an existing basement to comfortable conditioned space.
- Finally, most foundation moisture problems are associated with poor exterior drainage. Proper surface drainage (slope away from foundation) and a foundation drainage system (per code) are keys to ensure the best outcome for below-grade spaces. Consult with a design professional as needed.

CONDITIONED CRAWLSPACE WALLS

Conditioned crawlspaces are just like conditioned basements, except they are not as deep and a slab-on-grade is not required (although a ground vapor barrier is always required). Conditioned crawlspaces are different from vented crawlspaces in that the entire floor system above does not require insulation. Instead, only the crawlspace walls are insulated and the space is conditioned (usually with a couple of HVAC supply registers). This approach simplifies construction, improves comfort of the floor above, and better controls moisture in the crawlspace and in the floor above. Because conditioned crawlspaces walls are no different than basement walls (other than they are typically unfinished), the same insulation details apply.

Figure 2 is similar to Figure 1, and Figure 3 shows a detail for exterior insulation with FPIS ci that is continuous with the above grade wall insulation. (This can allow for the band and sill to remain uninsulated on the interior side.) While a slab-on-grade inside the crawlspace is not required by code, the ground surface must still be treated with an aggregate layer (drainage and capillary break) as well as a ground vapor barrier (e.g., 6 mil poly) as required by code. It is important that the ground vapor barrier is secured and sealed to the foundation wall and all joints are taped. Finally, termite control and inspection measures may require consideration, particularly in areas subject to "very heavy" termite infestation probability.[1]

Figure 2.

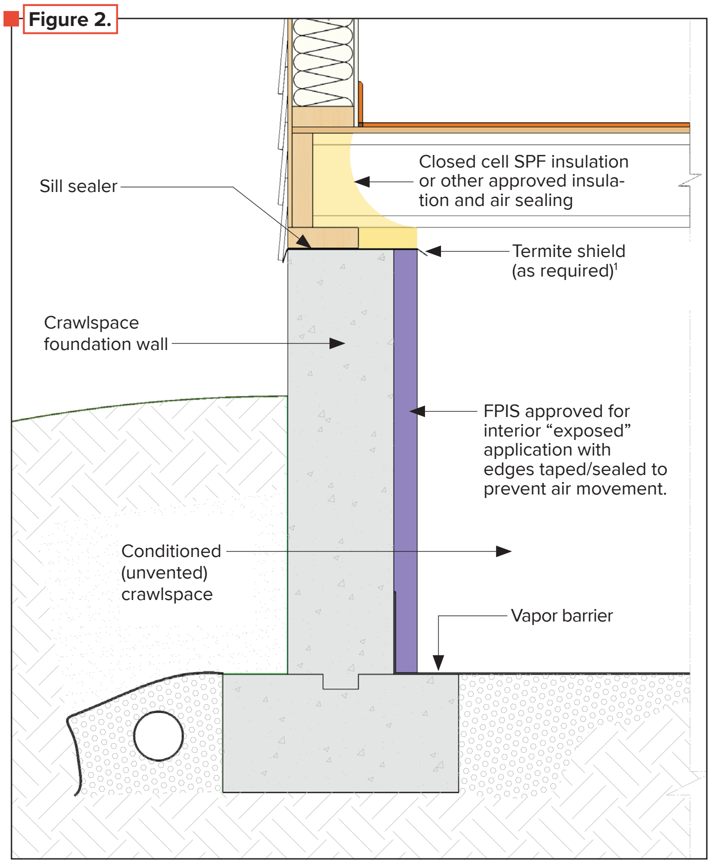
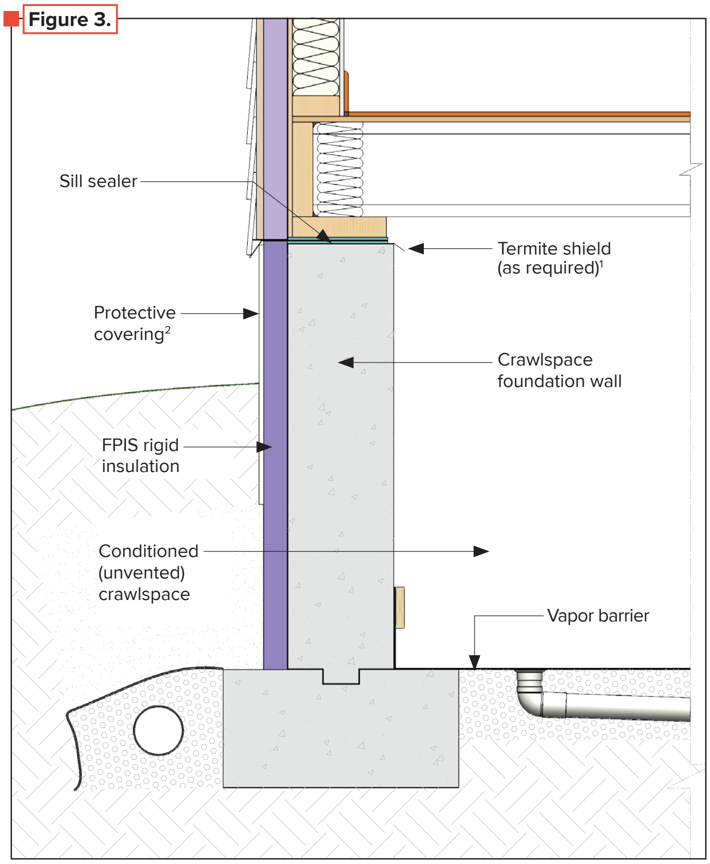


Figure 3.



[1] The foundation images provided in this document feature the use of a termite shield as a means to allow for visual inspection of termite shelter tubes. These should be combined with conventional use of termite soil treatment. Some localities or pest control operators may require alternate approaches like a termite inspection strip, a gap with no insulation, or removable insulation. For additional information refer to ABTG Research Report 1703-09, Protection of Wood-Frame Homes from Subterranean Termites: Evaluation of Building Code Provisions and Recommended Improvements.

[2] A protective covering is required to prevent physical and UV damage to exterior above grade foundation insulation. Typical protective coverings include fiber cement board, treated plywood, and metal or plastic composite panels.

SLAB-ON-GRADE

Slab-on-grade foundations generally come in two varieties: monolithic thickened edge slab (see Figure 4) and independent slab and stem wall (see Figure 5). A monolithic slab usually requires that the FPIS insulation be placed on the exterior edge. Such slabs are common in warm to mild climates where frost depths are shallow, unless the insulation is also detailed to protect the foundation from frost heave (see next section). An independent slab and stem wall foundation gives flexibility to insulate the slab only or the stem wall only (on its interior, exterior, or both sides).

The most significant detailing concern is to ensure that the vertical insulation is continuous, and there is not a thermal bridge pathway through the slab edge and stem wall to the exterior. Such thermal bridges (see Figure 6) significantly increase heat loss, discomfort, and slab condensation. While often overlooked, this detailing is required by code-prescribed slab insulation requirements. Consult a design professional for detailing options to avoid or minimize thermal bridging as needed.

Figure 4.

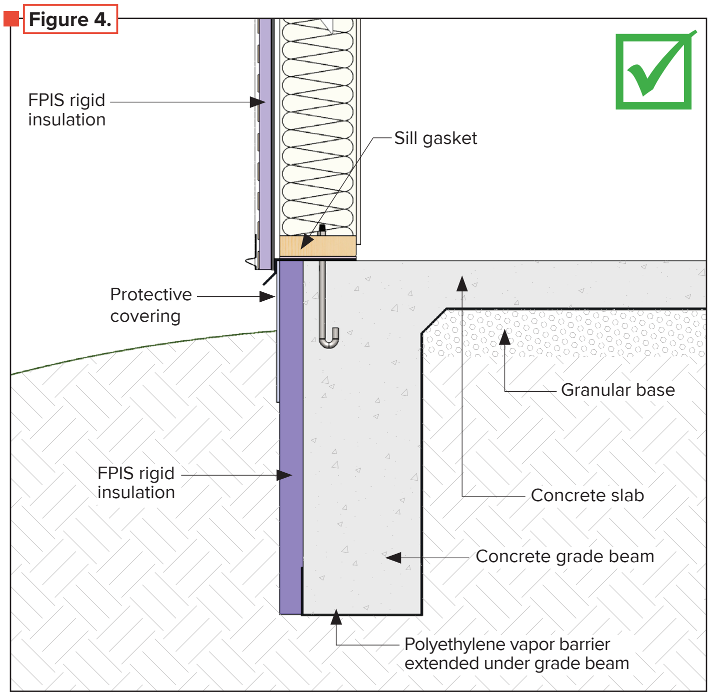


Figure 5.

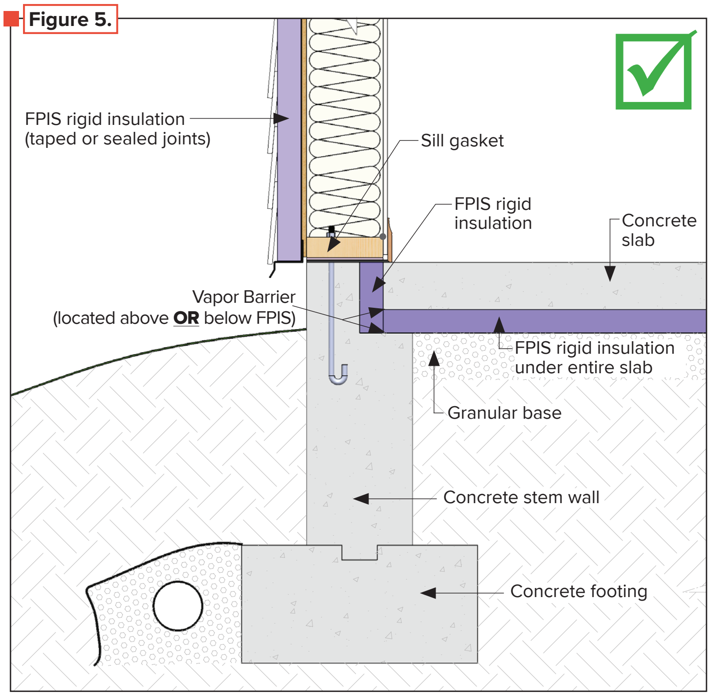


Figure 6.

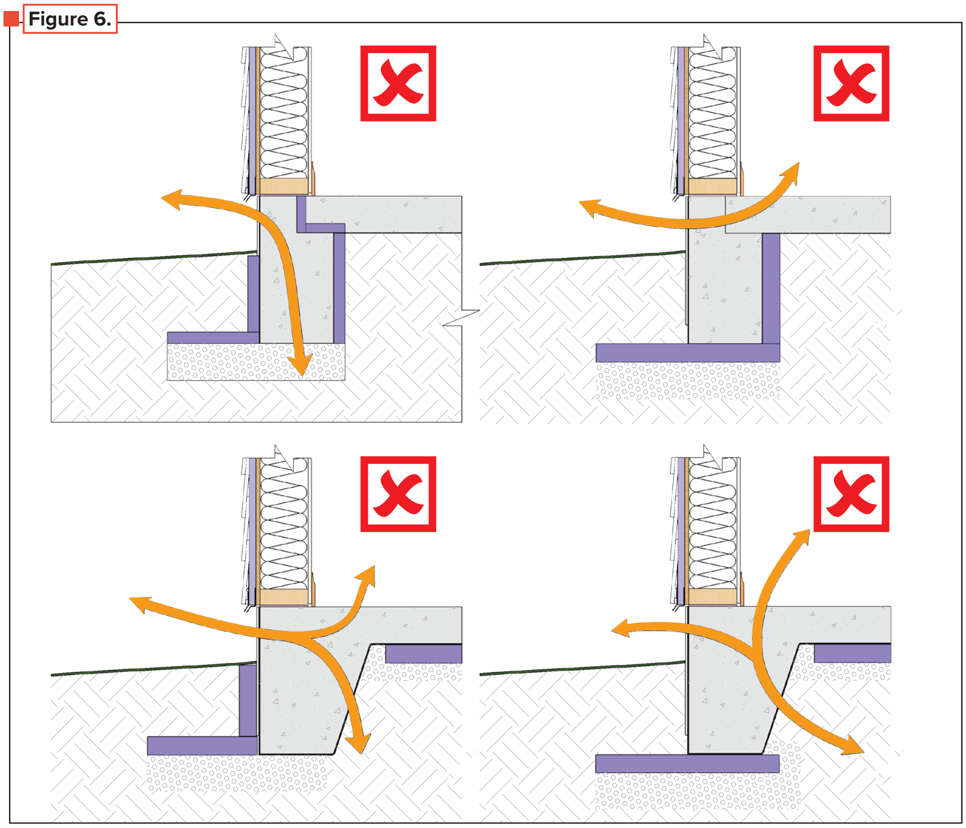


Illustration of common thermal bridges to avoid for conventional and FPSF foundations as applicable.

FROST-PROTECTED SHALLOW FOUNDATIONS

Frost-protected shallow foundations (FPSF) have been used on millions of commercial and residential buildings in Europe and the U.S. for decades and have consistently saved thousands of dollars in construction cost in areas where ground frost depths are more than a couple feet deep. The FPSF approach has been a recognized foundation construction method in U.S. model building codes since 1995. The strategically placed foundation insulation serves double-duty: increasing energy efficiency and effectively raising the frost depth by keeping the ground warm as though the footings are located in a warm climate.

Even in the coldest climates of the U.S. where frost depths exceed six feet, the FPSF footing depth can be as shallow as 16 inches, just like a "Florida slab." The FPSF method does not, however, apply to permafrost regions. Also, the insulation R-value requirements must satisfy both the local energy code and FPSF requirements that vary by coldness of climate based on a 100-year air-freezing index map (also see Additional Resources).

The basic insulation approach for three types of FPSF foundations are shown in Figures 7-9. They are only slight modifications of those shown in the previous sections for conditioned crawlspaces and slabs-on-grade. For example, the "wing" insulation shown in the figures is not required in climates that are moderately cold with moderate frost depths (unless needed to comply with the energy code's vertical/horizontal insulation dimension). Also, Figure 8 shows a permanent wood foundation stem wall, which is a code-recognized method, but the same insulation detail can be applied to more common masonry or concrete stem walls.

ADDITIONAL RESOURCES

This Quick Guide provides a primer for effective foundation insulation practices. The following resources can help you bring them into reality with proper specifications meeting code requirements:

- R-value requirements of the 2024 International Energy Conservation Code (IECC) and 2024 International Residential Code (IRC) Chapter 11
- ORNL Foundation Handbook
- ASCE 32 – Standard for FPSF
- Builder's Guide to Frost-Protected Shallow Foundations (FPSF)
- DOE Building America Solutions – Slab Edge Insulation

Figure 7.

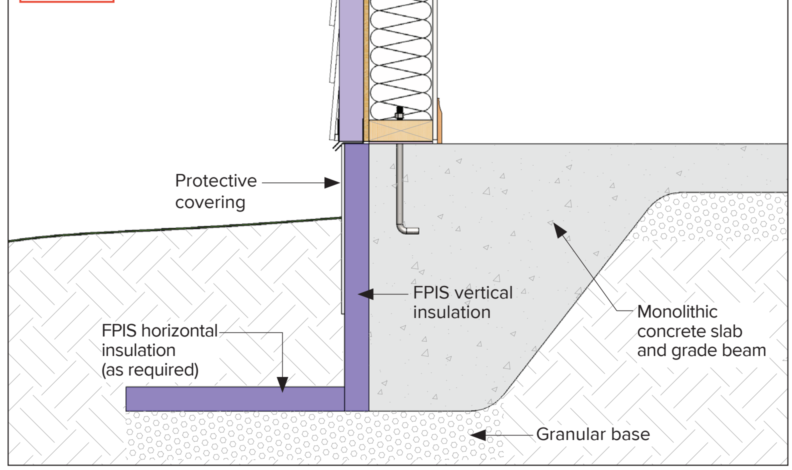


Figure 8.

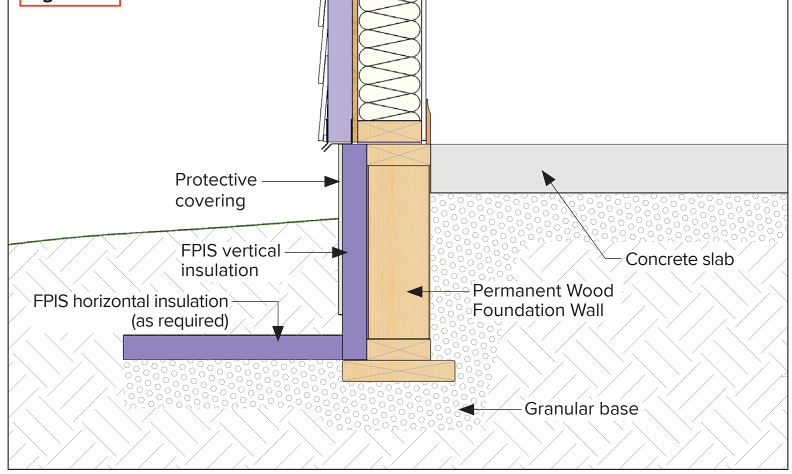
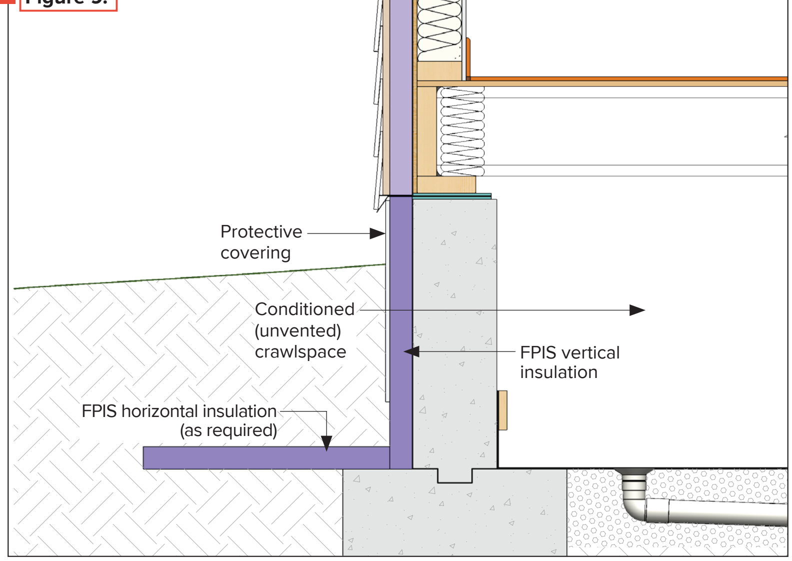


Figure 9.



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FACTS | Foam Plastic Applications for Better Building

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Building Decarbonization Insights

Quantifying the Energy & Carbon Saving Benefits of Foam Plastic Insulating Sheathing (FPIS)

WHAT IS THE PROBLEM?

Science is foundational to our understanding of global climate change. Likewise, science should guide us to a realistic approach to mitigate climate change by the use of insulation materials to decarbonize buildings. For example, the manufacturing of all modern U.S. building insulation materials, including foam plastics, accounts for about 0.01% of total annual global greenhouse gas (GHG) emissions – also referred to as embodied emissions,[1] global warming potential (GWP), or "carbon footprint." (**See Figure 2 on page 2.**) Yet, these same insulation materials have a carbon-saving "handprint" that helps to minimize the 300 times greater amount of annual GHG emissions from the operational energy use of all existing buildings in the U.S.

- **What do these scientific realities mean for the climate and for the specification of insulation to help decarbonize new and existing buildings?**
- **How does the carbon footprint (impact) and handprint (benefit) of building insulation materials, like foam plastics, come out in the balance?**

WHAT IS THE SOLUTION?

By putting sound science into practice, the above questions can be answered by considering the following win-win-win solution to building decarbonization with modern insulation materials:

Win #1: Energy Efficiency – All modern insulation materials play a crucial role in the energy efficiency of buildings to help reduce energy demand and facilitate an achievable, cost-effective, economy-wide transition to cleaner energy sources. (**See Section 1.**)

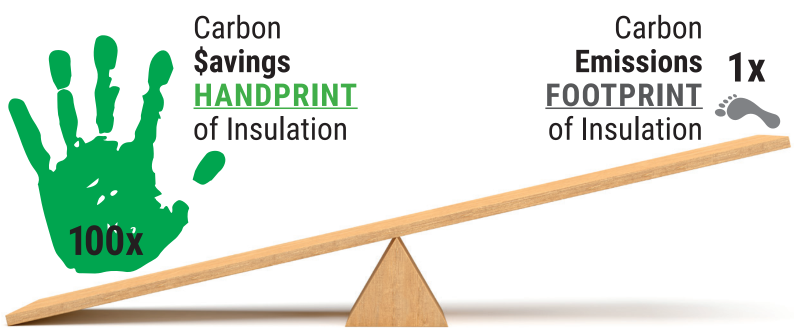


Figure 1. The carbon savings handprint of building insulation outweighs its carbon emissions footprint by 100x.

Win #2: Reduced Total Carbon Emissions – All modern building insulation materials used to achieve Win #1 have insignificantly different GWP impacts (footprint) in comparison to their building operational carbon-saving benefits (handprint). GWP alone is an incomplete and inadequate basis for the specification of insulation materials. The carbon-saving handprint of all modern insulation materials is nominally 100x greater than their comparatively small carbon material emissions footprint (see Figure 1). Furthermore, that small initial embodied carbon footprint of the insulation is typically paid back within the first year of building operation. This is true for all insulation materials, including today's foam plastics. (**See Section 2.**)

Win #3: Building Cost & Performance Optimization – FPIS is somewhat unique in that it is more than just insulation and its carbon-savings benefits cannot be measured merely by its GWP. It contributes to more cost savings, energy savings, and carbon emissions reductions when its multi-functional capabilities are leveraged to optimize the design of buildings. Optimizing building assemblies with the multifunctional capabilities of FPIS is a pathway to even greater energy and carbon emission reductions through integrated building design efficiencies. (**See Section 3.**)

Review "Key Take-Aways for Building Decarbonization Programs, Policies & Designs" on page 6 for implementation guidance.

[1] Embodied carbon represents the emissions that occur in the creation, transportation, installation, use, re-use, and disposal of materials through its full life-cycle. Those embodied emissions that occur up to the point of use are known as "up front" emissions (i.e., they occur upstream from and prior to the actual end use, such as a building). Embodied carbon is also characterized as the carbon footprint of a product.

THE BIG PICTURE

First, let's consider the big picture with regard to U.S. building materials and how they relate to global climate change in a practical, science-based manner:

- Figure 2 below shows total annual global GHG emissions: **about 59 gigatons (Gt) of CO2e**.[2]
- Inset in that figure is the 10% of annual global GHG emissions that originate in the U.S.: **about 6 GtC02e**.
- Within the U.S. portion, there is a multi-colored ribbon depicting the U.S. emissions associated with building and construction materials (including infrastructure uses): **about 0.36 GtCO2e or 0.6% of total annual global emissions**.
- The data is then broken down by specific building materials (concrete, gypsum board, steel, etc.). Of special note, the total annual production of building insulation materials in the U.S. represents an **estimated 0.01% of total annual global emissions**. Yet, as will be illustrated in **Section 2**, these emissions are eclipsed by the carbon savings and rapid carbon payback that occurs soon after these insulation products are put to use in buildings.

When we only focus on the relatively small embodied carbon or GWP contribution of insulation materials to global GHG emissions, we fail to capture the uniquely important role these products have in the decarbonization of buildings as a result of the large operational carbon savings they produce every year for the lifetime of a well-insulated building. Furthermore, selecting insulation materials merely on the basis of small differences in their GWP can cause missed opportunities to specify multi-functional insulation materials that help optimize building performance, efficient material usage, cost, and total carbon savings (**see Section 3**).

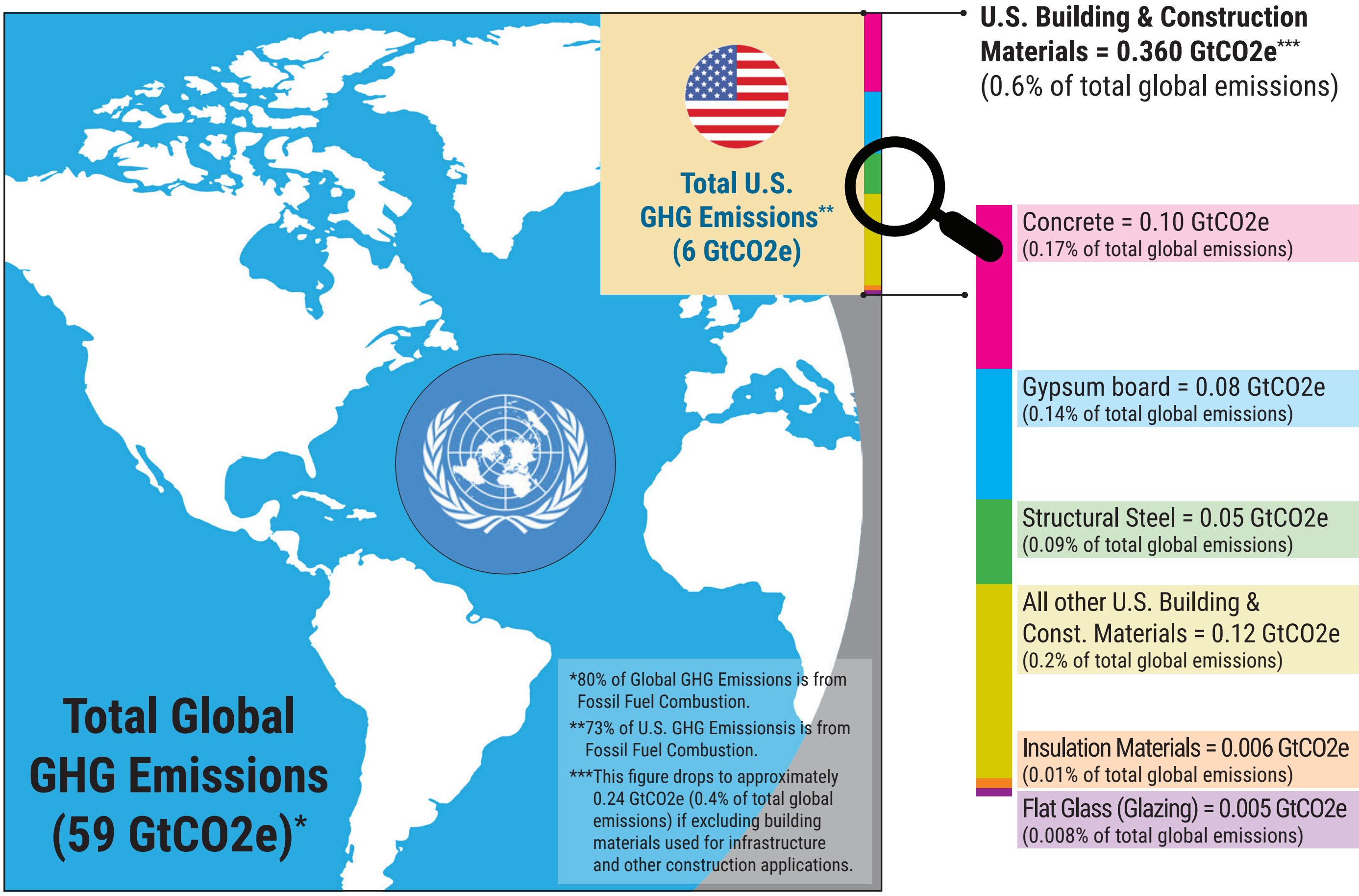


Figure 2. Magnitude of total global and U.S. GHG emissions, and contribution of U.S. Building & Construction Materials to total global GHG emissions.

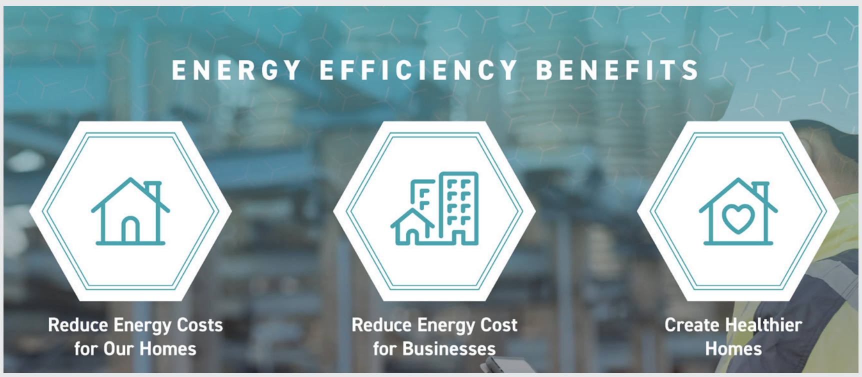
Source: ABTG Report: Decarbonization of Buildings, Figure A and Table A.

[2] 1 Gt of CO2e emissions is equivalent to emissions from the combustion of about 110 billion gallons of gasoline. A gigaton is one billion metric tons or one trillion kilograms.

1. EFFICIENCY FIRST!

Energy efficiency is:

- The lowest-cost, zero-carbon "fuel" because energy not used has no cost and no emissions.
- One of two key pillars for decarbonization on a broad scale, across all economic sectors including buildings. The other pillar is clean energy sources. (See Figure 3.)
- The foundation for increased energy productivity, which means delivering the same product, service, or objective with less energy consumption.
- Ultimately affordable because it reduces energy bills and pays back an initial efficiency investment many times over during the life of the building. (See example below.)
- A key means to lower peak demand on the electric grid to better enable a more cost-effective and reliable transition to renewable energy resources together with the associated infrastructure changes needed to produce and distribute energy.
- A central measure to achieve energy security because the safest supply of energy is energy that is not needed.



EXAMPLE:

For mortgaged homes, the portion of the downpayment for insulation is recouped within the first year of building use after which there is a net positive cash flow for the insulation portion of the initial building cost. Consequently, a $400 downpayment for improved energy efficiency features of a typical home can yield $14,500 savings over the period of a 30-year mortgage based on ACC Fact Sheet "Energy Efficiency = Healthy Return on Investment."

In the context of well-insulated building thermal envelopes, energy efficiency is also the means to:

- Accommodate smaller, less costly heating and cooling equipment, resulting in less emissions associated with these building systems.
- Allow for electrification of building heating (instead of on-site fossil fuel combustion) by enabling the effective and expanded use of electric heat pump technology, particularly in climates with cold winters.
- Make buildings more resilient by better protecting occupants during power outages, particularly during periods of extreme weather.

In short, energy efficiency is crucial to affordable and resilient buildings, and it reliably reduces GHG operational emissions regardless of the energy source used. It is also a key, multi-faceted means to enable building decarbonization in coordination with the efforts to decarbonize other sectors of the U.S. economy such as the electrification of transportation, which relies on the same limited renewable energy resources.

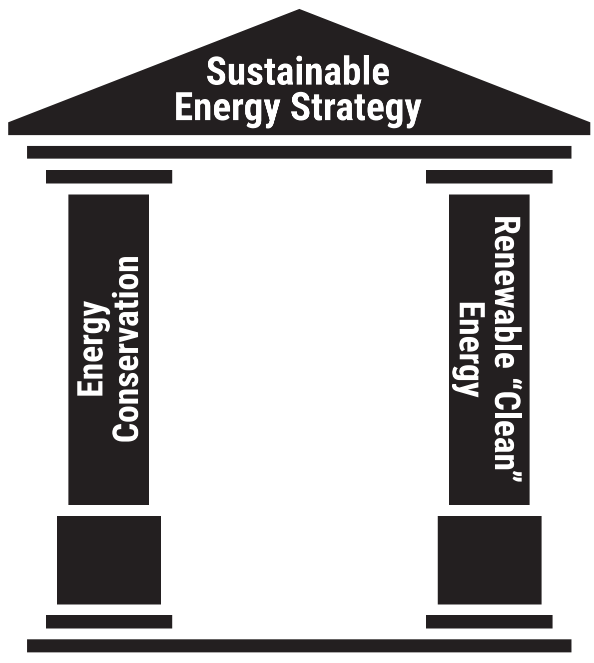


Figure 3. Twin pillars of a sustainable energy strategy.

Source: ABTG Report: Decarbonization of Buildings, Figure 39.

READMORE

See Section 4.3, The Foundational Role of Energy Efficiency, in the ABTG Report: Decarbonization of Buildings, which includes a summary of multiple references.

2. TOTAL CARBON (FOOTPRINT + HANDPRINT)[3]

Insulation materials, like other building materials, have an embodied carbon “footprint.” But unlike other building materials, insulation materials also have a “handprint” that saves energy and carbon emissions over the life of the building. These savings lower the cost of building operation. The benefits are well known and substantial for essentially all insulation materials used in residential and commercial construction. Data regarding the footprint and handprint of modern foam plastics, including FPIS products, are featured in Figures 4, 5, 6 and 7.

FPIS Material Innovations = Reduced Carbon Footprint

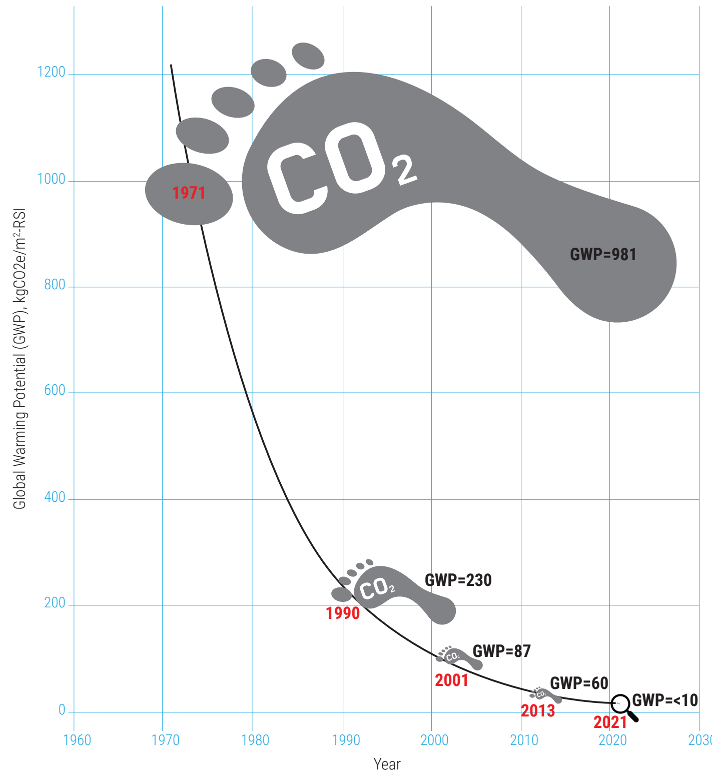


Figure 4.

Example of dramatic reductions in embodied carbon footprint from 1970s to present. Now, essentially all U.S. FPIS products have low GWP (i.e., <10 kgCO2e/m²-RSI).

Source: Unlocking Carbon Savings with Plastic Insulation Materials, Schmidt, A. and Chertack, A. (2024).

Total Carbon Savings: Handprint > Footprint

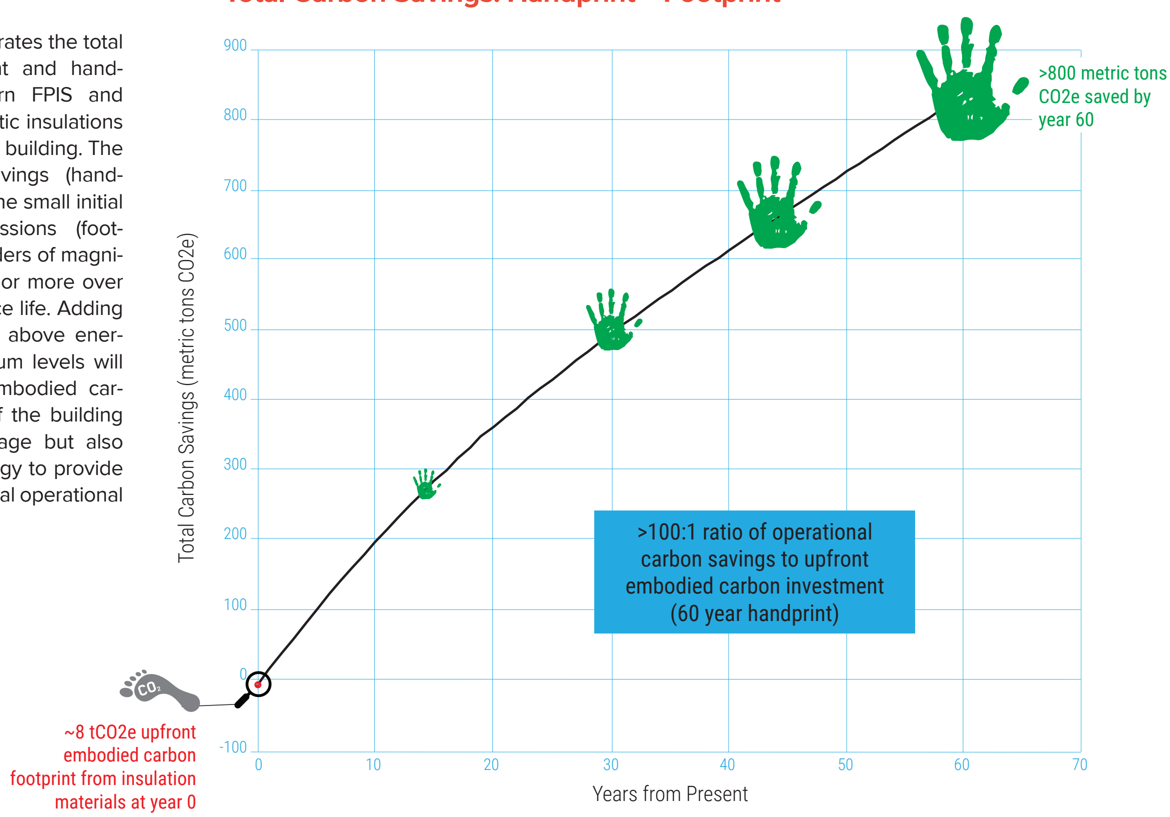


Figure 5.

This graph illustrates the total carbon footprint and handprint of modern FPIS and other foam plastic insulations used in a typical building. The net carbon savings (handprint) exceeds the small initial embodied emissions (footprint) by two orders of magnitude (i.e., 100x) or more over a 60-year service life. Adding more insulation above energy code minimum levels will increase the embodied carbon footprint of the building insulation package but also save more energy to provide greater or optimal operational carbon savings.

[3] A footprint is one way of expressing the embodied GHG emissions or global warming potential (GWP) associated with a manufactured material or product. Hence, it is a footprint that is left by the material, largely before it is used. The footprint is measured and reported in the form of environmental product declarations (EPDs). But, once a material arrives at its intended application (e.g., a building) and is put to use for its intended function (e.g., insulation to conserve energy during building operation), it then begins to create a “handprint” in the form of GHG emissions savings or avoidance during use. A “total carbon” approach considers both the footprint and the handprint of materials to properly assess their net impact or benefit to the climate. Such an approach is absolutely necessary to properly characterize the significant role of all insulation materials as a means for energy efficiency and building decarbonization.

Carbon Emissions Payback

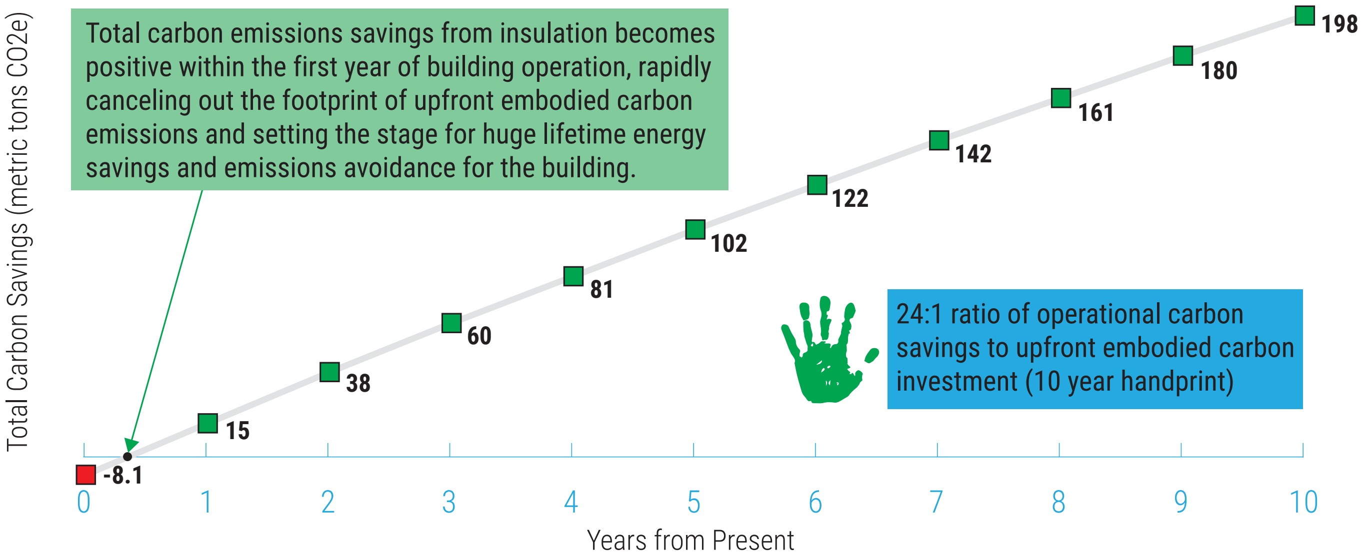


Figure 6. FPIS and other foam plastic building insulations pay back the initial upfront embodied carbon within the first year of building operation (see green arrow). This payback period is comparable to that of wind turbines for renewable electricity generation.[4] Within 10 years, the operational to embodied emissions savings ratio of the building insulation materials reaches 24:1 for immediate climate change mitigation with continued savings for additional long-term benefits.

A Key Material Comparison Take-Away

Different insulation materials also have very different functional attributes and building design capabilities, even within a given kind of insulation, which necessitate going beyond a narrow focus on small differences in GWP that are dwarfed by the total carbon savings.

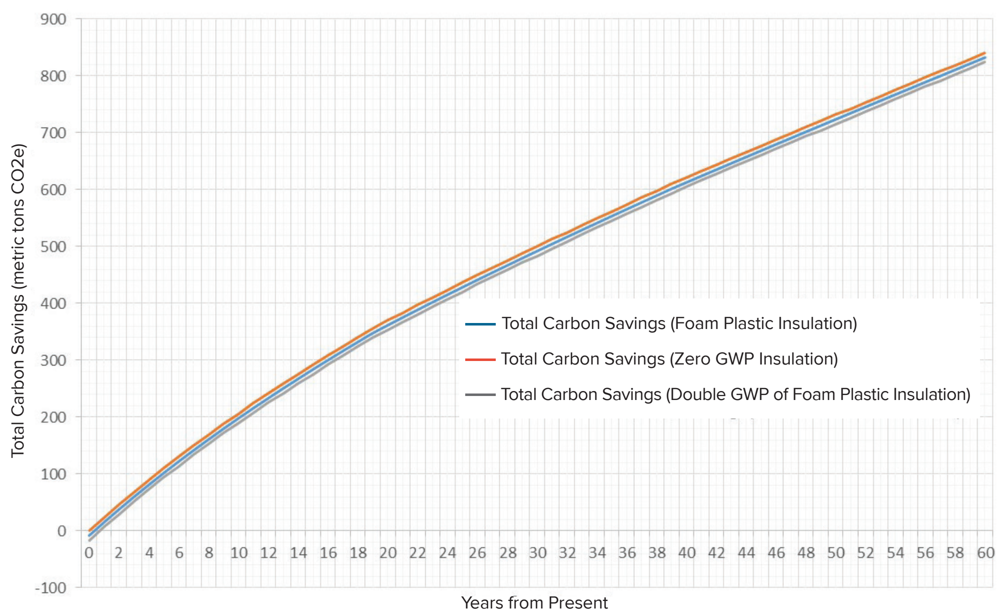


Figure 7. The total carbon savings (footprint and handprint) for all modern U.S. insulation materials are negligibly different in carbon payback period (all typically less than 1 year) and all produce huge cumulative total carbon savings during use that are essentially equivalent. All modern U.S. insulation materials have a major role to play in building energy efficiency and decarbonization, regardless of minor differences in embodied carbon footprint (as shown in these three representative cases).

READMORE

- See Sections 4.7, 4.8, and 4.9 of the ABTG Report: Decarbonization of Buildings.
- See Determination of Total Carbon Impact of Plastic Insulation Materials, ICF International, Inc. study (2023).
- See Unlocking Carbon Savings with Plastic Insulation Materials, Schmidt, A. and Chertack, A. (2024).

[4] The carbon handprint of a wind turbine is about 45x its initial carbon footprint over a 25-year service life. In other words, the footprint of a wind turbine is offset by its handprint within about 7 months after it is put into operation. This carbon savings payback is comparable to that of insulation materials as shown in Figures 5, 6, and 7. (Data Sources: Journal of Energy Conversion and Management, Elsevier and Yale University, School of the Environment)

3. MULTIFUNCTIONAL BENEFITS OF FOAM SHEATHING = MORE $AVINGS

The multifunctional capabilities of FPIS provide opportunities to optimize the thermal, moisture, and durability performance of building envelope assemblies while also reducing embodied carbon emissions for even greater total carbon savings than addressed in Section 2. Unlike the use of single-function insulation materials, FPIS products can serve multiple functions as illustrated in Figure 8, including continuous insulation, air barrier, water resistive barrier, thermal barrier, vapor control, foundation frost protection, and other functional benefits. Such applications of FPIS serve to reduce building air leakage, minimize structural thermal bridging, improve moisture resistance, and reduce heating/cooling equipment sizes. Consequently, it helps to minimize the embodied carbon footprint of the overall building assembly through resource-efficient use or even elimination of other construction materials and their embodied carbon content. Multifunctional applications of FPIS can result in optimized assemblies that use fewer materials while maintaining or improving overall building performance with reduced total carbon emissions. For this reason, it is necessary to consider more than just the GWP of FPIS materials.

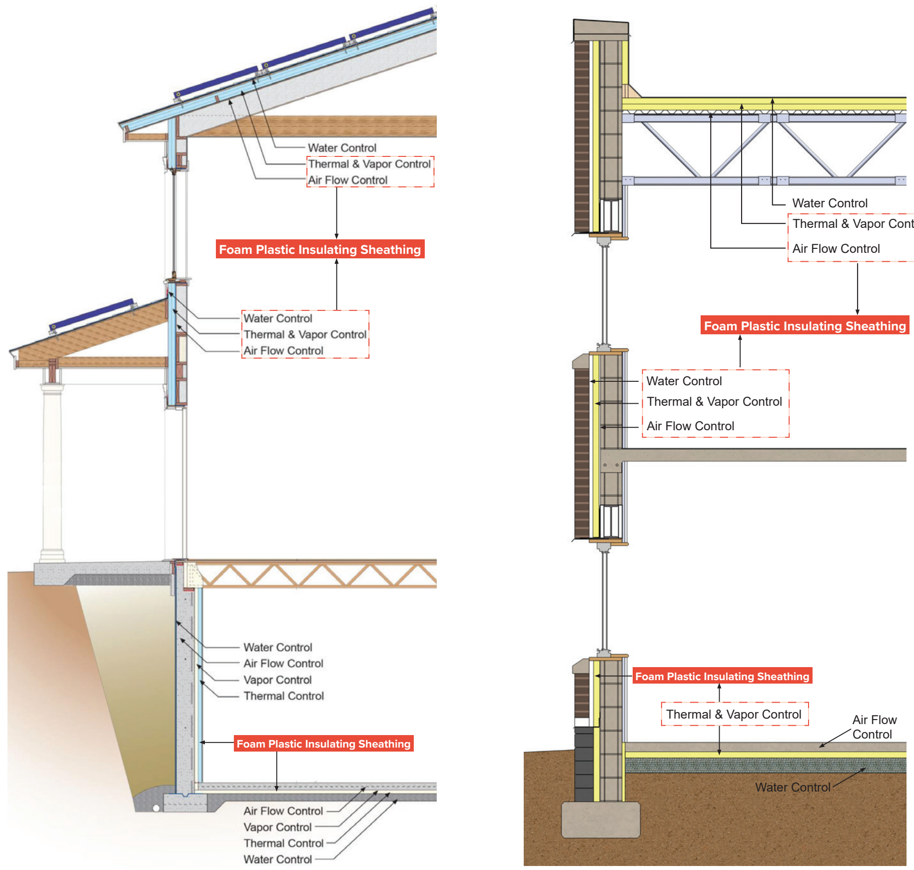


Figure 8.

Examples of multi-functional applications of FPIS in building thermal envelope assemblies.

Key Take-Aways for Building Decarbonization Programs, Policies & Designs

Based on the win-win-win propositions outlined above, the following actions should be taken for insulation materials to create effective programs, policies, and building designs:

1. Adopt criteria that encourage maximizing energy efficiency in buildings with high-performance insulation materials and increased levels of insulation. (See Section 1.)
2. Acknowledge that insulation products must be valued based on “total carbon” to better align with the purpose of insulation materials and the goals of decarbonization. This requires considering their embodied carbon footprint in view of their operational energy and carbon savings handprint. (See Section 2.)
3. Reward manufacturers of materials (like modern foam plastics), who have invested in research, development, and implementation of low-carbon material technologies and manufacturing process improvements. These investments are the bedrock of an innovation pathway to a low-carbon emissions future. They should not be penalized by policies that arbitrarily and indiscriminately deselect classes of materials on the narrow basis of a single metric such as the product’s global warming potential (GWP) without considering its total carbon footprint and handprint (see Section 2) and multi-functional building system capabilities (see Section 3).
4. Capitalize on the multi-functional benefits of materials, like many modern foam plastics, that serve as a means to optimize the cost-effectiveness, resource efficiency, construction efficiency, performance, resiliency, and durability of building systems. (See Section 3.)

Find free wall calculators for energy and building code compliance at continuousinsulation.org/calculators

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- Cladding Connections
- Fire Performance
- Foundation Insulation & Frost Protection
- Healthy Buildings
- Remodeling for Energy Efficiency
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- Thermal Insulation
- Water Resistive Barrier
- Water Vapor Control
- Window Installation

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