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**.)

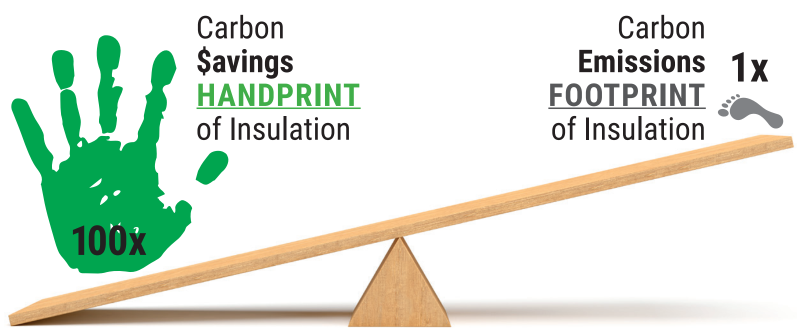


Figure 1. The carbon savings handprint of building insulation outweighs its carbon emissions footprint by 100x.

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**).

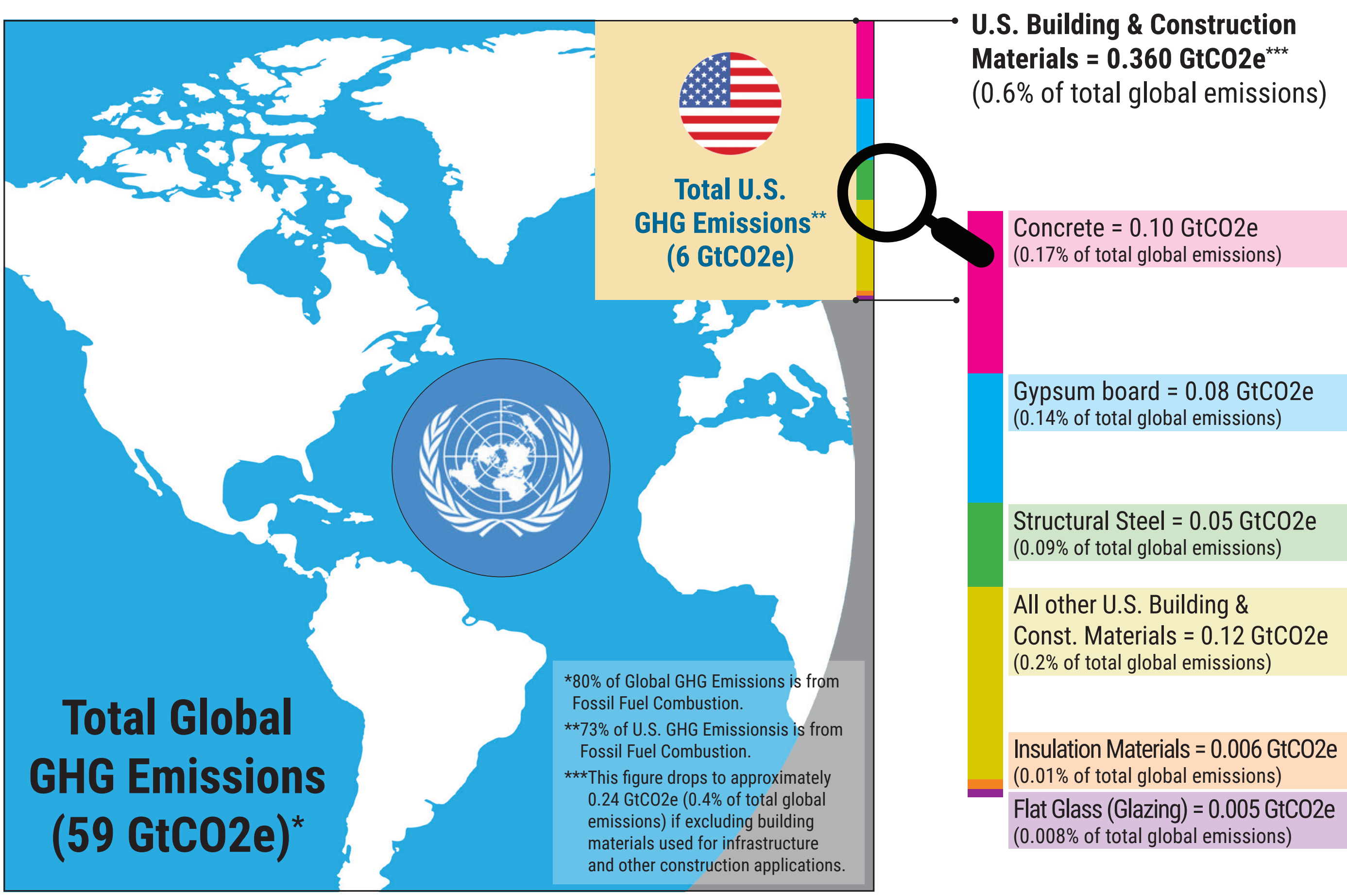


Figure 2. Magnitude of total global and U.S. GHG emissions, and contribution of U.S. Building & Construction Materials to total global GHG emissions.

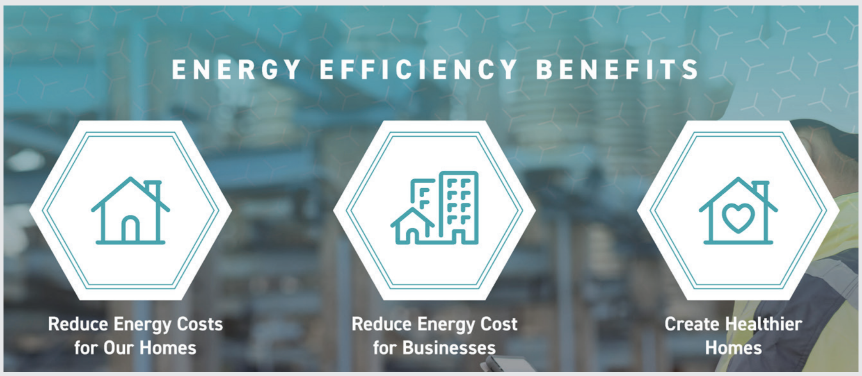
Source: ABTG Report: Decarbonization of Buildings, Figure A and Table A.

[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.

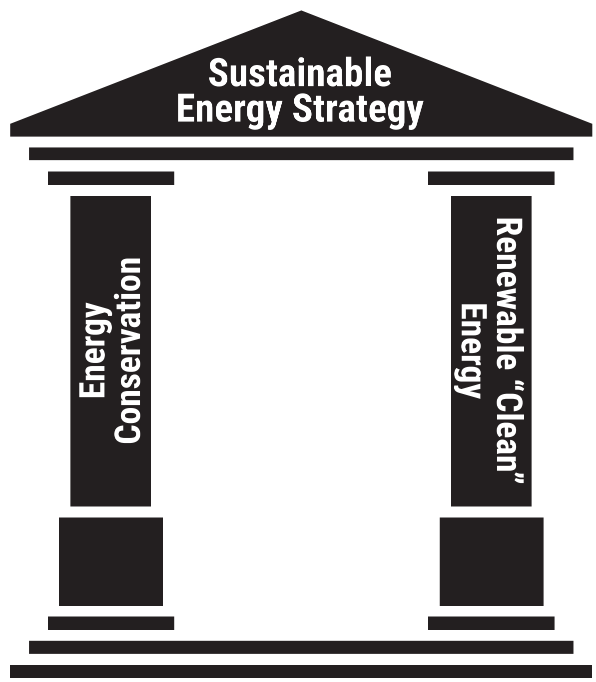


Figure 3. Twin pillars of a sustainable energy strategy.

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.

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 $kgCO_2e/m^2$-RSI).

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

FPIS Material Innovations = Reduced Carbon Footprint

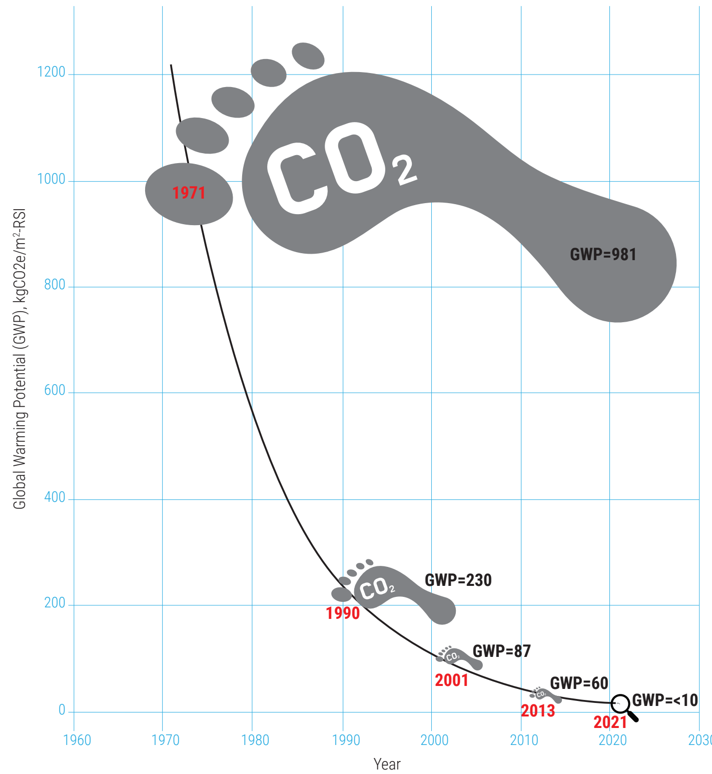
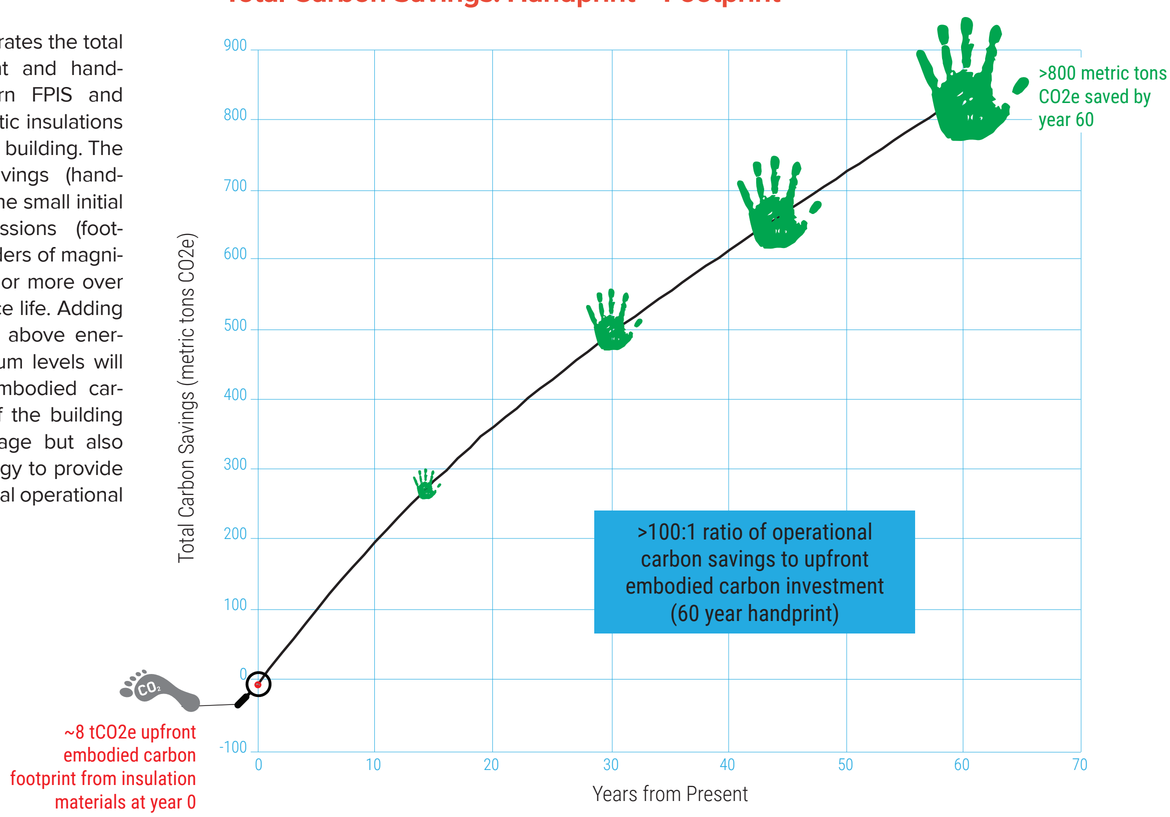


Figure 5.

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.

Total Carbon Savings: Handprint > Footprint



[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

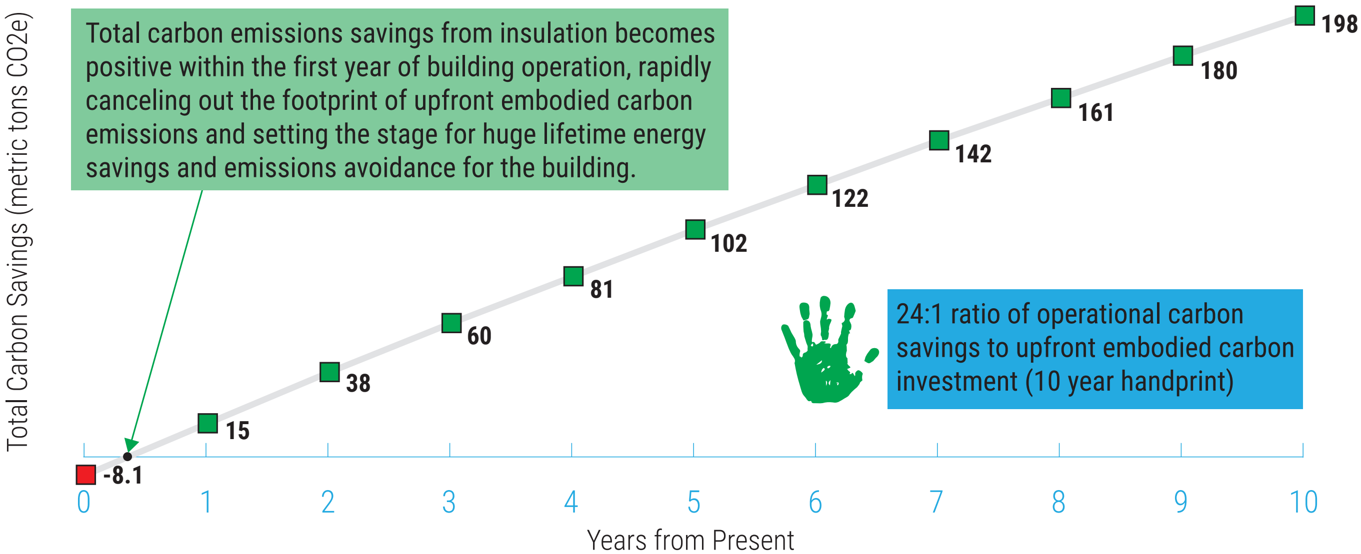


Figure 6. FPIS and other foam plastic building insulations pay back the initial upfront embodied carbon within the first year of building operation (see green arrow). This payback period is comparable to that of wind turbines for renewable electricity generation.[4] Within 10 years, the operational to 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.

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.

A Key Material Comparison Take-Away

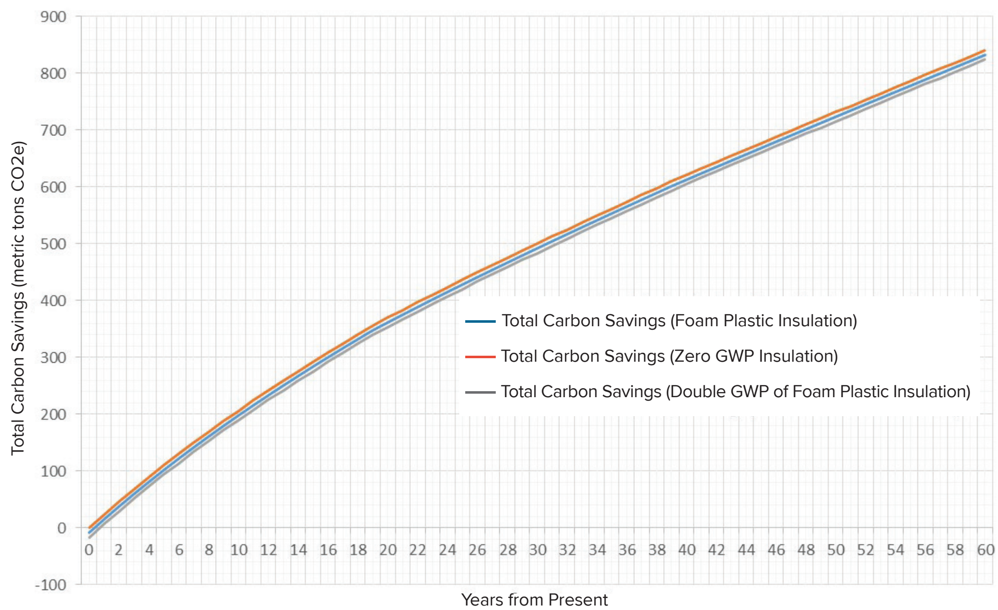


Figure 7. The total carbon savings (footprint and handprint) for all modern U.S. insulation materials are negligibly different in carbon payback period (all typically less than 1 year) and all produce huge cumulative total carbon savings during use that are essentially equivalent. All modern U.S. insulation 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).

THINK**ABOUT**IT?

The carbon savings attributed to insulation materials during the operational life of a building are purposefully based on comparison to the same building without insulation because: (1) the embodied carbon is accounted for the full insulation amount as installed and, as a matter of consistency, (2) it is necessary to properly represent the full actual effect and function of the specified and installed insulation materials on whole building energy use and carbon emissions savings. This approach allows for consistent and realistic functional comparisons between different insulation materials and methods (or levels of insulation) in a given whole building application.

[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.

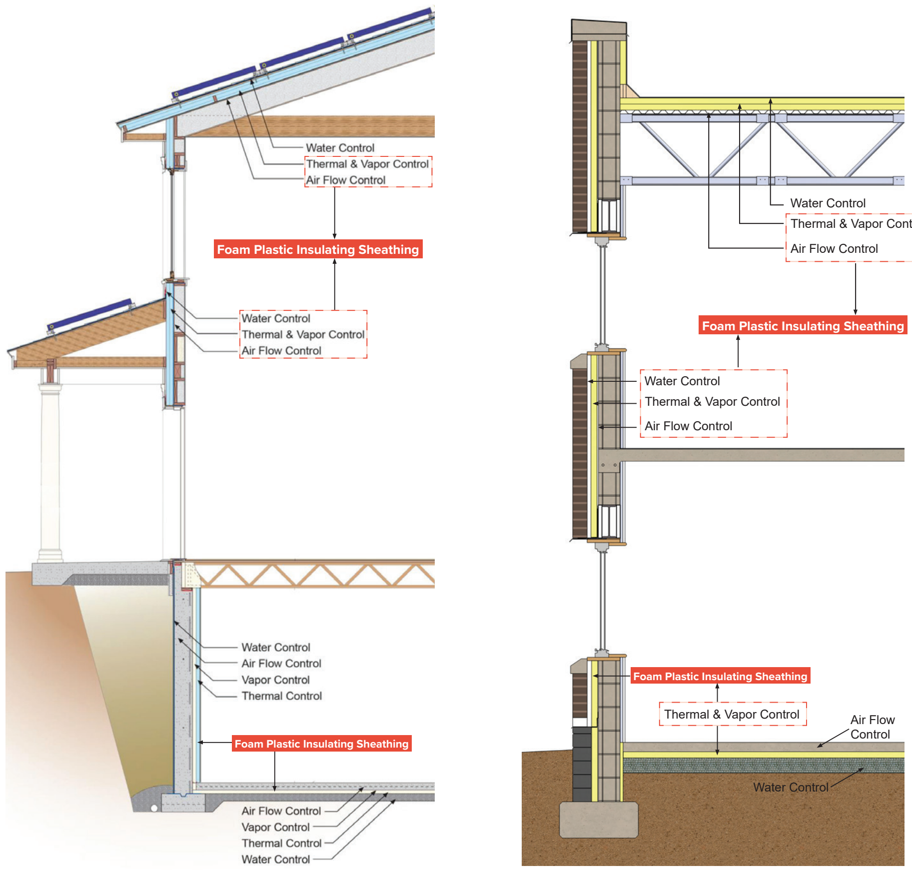


Figure 8.

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.)

Contact us.

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