Setting the Record Straight: Insulation and Low Carbon Buildings

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This guide aims to correct misleading carbon claims made by some cellulose and wood fiber insulation manufacturers. It highlights why commonly available, cost-effective fiberglass insulation is among the best building materials for low-carbon construction. The guide contains data from recent reports that examine the carbon impacts of various insulation materials during the production stage, use phase, and considerations for the end-of-life cycle for insulation products. By offering transparency and accurate citations, the analysis presented here brings clarity to the topic.

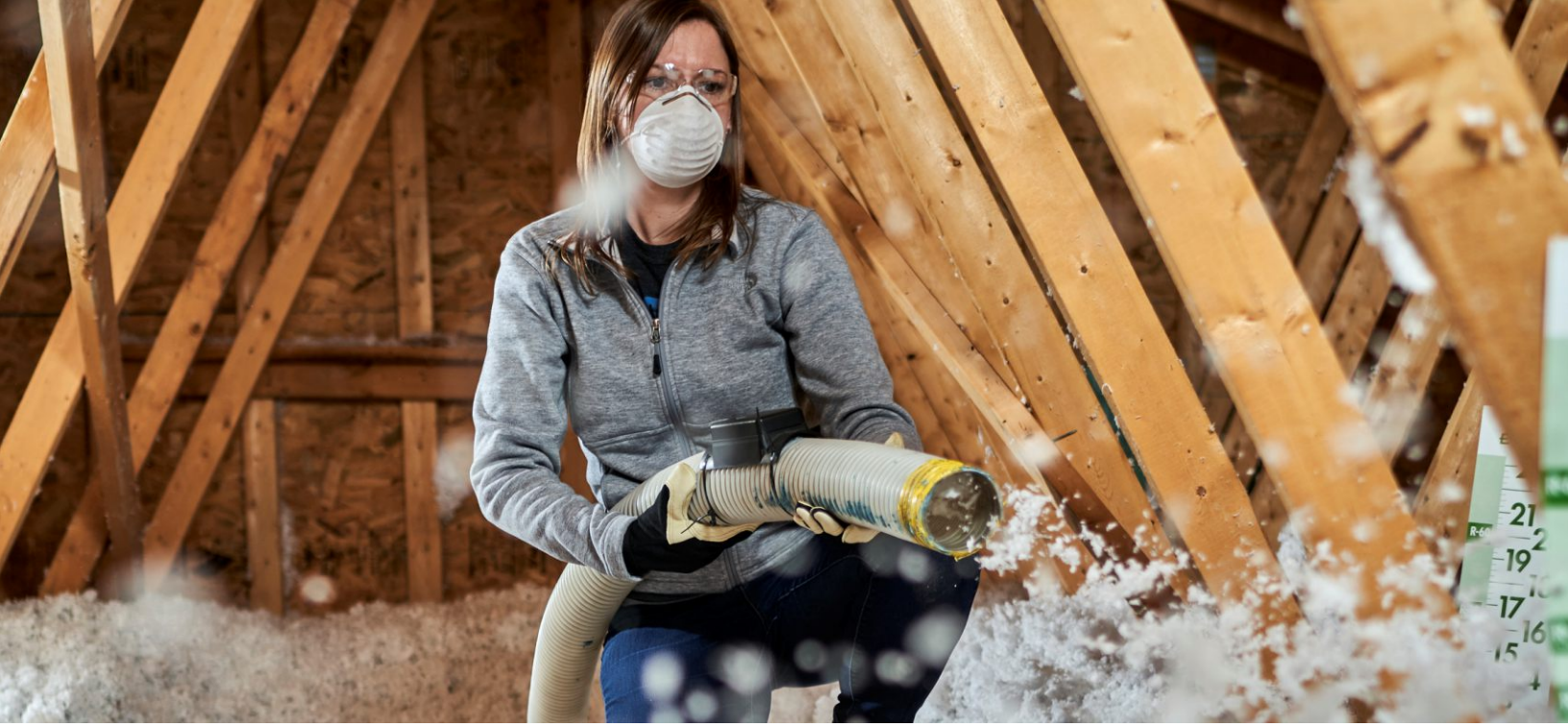
Strategy for Decarbonizing the Built Environment

Buildings account for more than one-third of total carbon emissions in the United States.[1] Achieving low-carbon construction of residential and commercial buildings means assessing carbon impacts in three primary areas: 1) the resulting impact from the production of materials, 2) the use phase carbon impact of building materials (operational carbon), and 3) the end-of-life cycle (landfill) climate impacts of products.

Insulation is Unique Among Building Products and Carbon Emissions

Government regulation and market interests increasingly drive consideration of product embodied carbon when making building material selections. For products like cement and concrete, there can be a wide variation in material embodied carbon. Insulation products, however, are unique: they are the only building material whose primary purpose is to reduce energy use. The embodied carbon resulting from the manufacture of insulation products is overtaken in a matter of months by these “use phase” emissions savings, and insulation continues to deliver carbon savings for the life of the building.

[1] “NREL Researchers Reveal How Buildings Across United States Do - and Could - Use Energy,” National Renewable Energy Laboratory, September 14, 2023, https://www.nrel.gov/news/features/2023/nrel-researchers-reveal-how-buildings-across-the-united-states-do-and-could-use-energy.html.



Cellulose and Wood Fiber Insulation Products are Not Carbon Negative

Certain cellulose and wood fiber insulation manufacturers market their products as carbon negative and, therefore, the best option for lowering building carbon emissions. They base this claim on the "biogenic carbon" savings that occur during the insulation material's useful life. Put another way, the woody biomass (newspaper, cardboard, or wood waste) they use temporarily stores carbon. What these manufacturers don't mention is that these temporary carbon savings are lost when cellulose and wood fiber insulation products are landfilled at the end of their useful life, and that "stored" carbon degrades and is released back into the environment.

These marketing claims are false and are not supported by publicly available environmental product declarations for cellulose and wood fiber insulation. As evidenced in the ICF study of cellulose EPDs, when put to a 3rd party assessment, cellulose products publish a positive embodied carbon value.[2]

> "Wood Fiber Insulation is a Scalable Insulation Solution that is Carbon Negative"
>
> - TimberHP[3]

FALSE

> "Cellulose can have a GWP of less than zero."
>
> - Greenfiber Insulation[4]

FALSE

[2] Sustainable Minds, CIMA/CMAC, December 23, 2019, "Industry-wide Type III EPD, Conventional Loose-Fill Cellulose Insulation," https://transparencycatalog.com/assets/uploads/pdf/cima-cimac-Conventional-Loose-Fill-Cellulose-Insulation_EPD.pdf.

[3] "Wood Fiber Insulation is a Scalable Insulation Solution that is Carbon Negative," TimberHP, Accessed October 24, 2024, https://www.timberhp.com/why-timberhp/healthy-planet.

[4] "Embodied Carbon and the Built Environment: Get the Facts, Case Studies, Sustainability," Greenfiber, June 14, 2022, https://www.greenfiber.com/blog/embodied-carbon-and-the-built-environment-get-the-facts#:~:text=Due%20to%20low%20energy%20intensity%20to%20manufacture%20and,can%20have%20a%20GWP%20of%20less%20than%20zero.

Comparing the Embodied Carbon of Insulation Products

Analysts at ICF compared the embodied carbon of the most used cavity and exterior sheathing building insulation materials. Where available, ICF used industry-wide Environmental Product Declarations (EPDs) for comparison. EPDs are likened to nutrition labels for products, giving numbers to the environmental impacts of their creation. EPDs are verified by 3rd party practitioners, and results are derived from actual production data for a given product. For insulation materials with no available industry-average data, manufacturer-specific EPD values were used. Cellulose batt and wood fiber insulation products sold in North America do not have EPDs that allow for embodied carbon comparisons.

As the table on the following page illustrates, there is a range in the embodied carbon of insulation materials, with cellulose loose fill and both fiberglass loose fill and batt insulation products having the lowest embodied carbon for cavity insulation materials.[5] While it may be easy to make selections based on these products being ranked from lowest to highest embodied carbon, this is only part of the picture. It is crucial, however, to consider both embodied carbon and use phase operational carbon when considering the total carbon contribution to a building.

[5] ICF, October, 2024, "Carbon Payback Scenario Analysis," p. 10, https://insulationinstitute.org/wp-content/uploads/2024/10/102224-NAIMA-Carbon-Payback-Period-Analysis.pdf.

Insulation Provides Rapid Carbon Payback

Because all insulation products reduce energy use in all buildings, virtually all have rapid carbon payback periods. ICF's analysis shows that the average carbon payback period for whole building insulation in residential and commercial prototypes is generally under a year for all investigated products.

The table below reflects ICF's findings on the average carbon payback period for a single-family home prototype in all climate zones. For colder climate zones with more heating days, the payback period for insulation use is quicker than in warm weather climate zones.

For fiberglass batt and blown insulation products, the embodied carbon payback period average across all climate zones is 46 days, compared with 25 days for cellulose loose fill insulation. Even for high density mineral wool board insulation, the carbon payback period is measured in months rather than years.

Carbon Payback Period for Residential Insulation Products[6]

Insulation Material	Embodied Carbon (kg Co_2e per FU)	Carbon Payback Period (Months)																
U.S. Climate Zones		1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8	ALL
Cellulose Loose Fill	0.61	2.0	1.6	1.1	1.1	1.1	1.3	0.9	1.0	1.0	0.7	0.8	0.9	0.6	0.6	0.5	0.4	0.8
Fiber Glass Loose Fill	1.07	3.5	2.8	1.9	1.9	2.0	2.3	1.6	1.7	1.8	1.3	1.3	1.6	1.0	1.1	0.9	0.7	1.5
Fiber Glass (Unfaced) Batts	1.08	3.6	2.8	1.9	2.0	2.0	2.3	1.6	1.8	1.8	1.3	1.4	1.7	1.0	1.1	0.9	0.7	1.5
HFC (Open Cell) Spray Foam	1.68	5.5	4.4	3.0	3.0	3.1	3.6	2.5	2.7	2.8	2.0	2.1	2.6	1.6	1.7	1.4	1.2	2.3
HFO (Open Cell) Spray Foam	1.68	5.5	4.4	3.0	3.0	3.1	3.6	2.5	2.7	2.8	2.0	2.1	2.6	1.6	1.7	1.4	1.2	2.3
Mineral Wool Loose Fill	2.07	6.8	5.4	3.7	3.8	3.9	4.5	3.1	3.4	3.5	2.4	2.6	3.2	1.9	2.1	1.7	1.4	2.8
Sheep's Wool Batts	3.11	10.3	8.1	5.6	5.6	5.8	6.8	4.6	5.0	5.2	3.7	3.9	4.8	2.9	3.2	2.6	2.2	4.3
HFO (Closed Cell) Spray Foam	4.21	14.0	11.0	7.6	7.6	7.8	9.1	6.3	6.8	7.1	5.0	5.3	6.5	3.9	4.3	3.5	2.9	5.8
Mineral Wool (Light Board) Batts	4.22	14.1	11.1	7.6	7.7	7.9	9.2	6.3	6.8	7.1	5.0	5.3	6.5	3.9	4.4	3.5	2.9	5.8
HFC (Closed Cell) Spray Foam	11.07	40.8	30.2	20.3	20.5	21.0	24.6	16.7	18.2	18.9	13.1	13.9	17.2	10.3	11.4	9.2	7.7	15.3
Cellulose Batts	N/A																	
Wood Fiber Batts	N/A																	
Wood Fiber Loose Fill	N/A																	
Phenolic Foam	1.62	5.4	4.2	2.9	2.9	3.0	3.5	2.4	2.6	2.7	1.9	2.0	2.5	1.5	1.7	1.3	1.1	2.2
Polyisocyanurate - Roof Foam	2.30	7.6	6.0	4.1	4.2	4.3	5.0	3.4	3.7	3.9	2.7	2.9	3.5	2.1	2.4	1.9	1.6	3.2
EPS Board	2.80	9.2	7.3	5.0	5.1	5.2	6.1	4.2	4.5	4.7	3.3	3.5	4.3	2.6	2.9	2.3	1.9	3.8
Polyisocyanurate - Well Foam	4.29	14.3	11.2	7.7	7.8	8.0	9.3	6.4	6.9	7.2	5.1	5.4	6.6	4.0	4.4	3.6	3.0	5.9
XPS Board	5.08	17.1	13.4	9.1	9.2	9.5	11.0	7.6	8.2	8.6	6.0	6.4	7.8	4.7	5.2	4.2	3.5	7.0
Mineral Wool (heavy density) Board	7.97	27.4	21.3	14.5	14.6	15.0	17.6	11.9	12.9	13.5	9.4	10.0	12.3	7.4	8.2	6.6	5.5	10.9
Wood Fiber Board	N/A																	

[6] Ibid

Why Do Some Insulation Products Have High Embodied Carbon?

The industry-wide EPDs used for comparing the embodied carbon of insulation products represent industry averages. Some manufacturers produce materials with substantially lower carbon footprints than the industry average. Still, some insulation materials fare poorly compared to alternative products used in the same application.

For example, some closed cell spray foam products use hydrofluorocarbons (HFCs) as a blowing agent. HFCs are ozone depleting and have a very high global warming potential. While these products are being phased out under international climate treaties, users should be aware that these high embodied carbon products continue to be commercially available.[7]

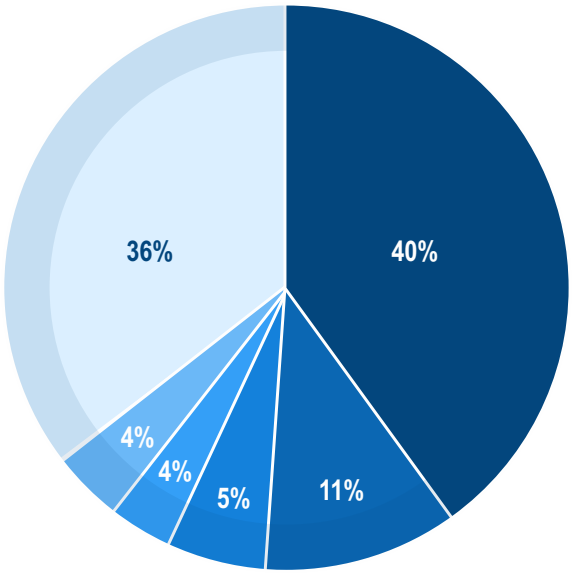
Unlike other insulation board products, mineral wool board insulation is impermeable to fire and is therefore used in applications where fire performance is required. Such applications include high rise buildings and buildings in fire-prone areas. The embodied carbon footprint must be balanced against instances where fire performance is a primary consideration in product selection.

Is Insulation a Major Contributor to a Building's Total Embodied Carbon?

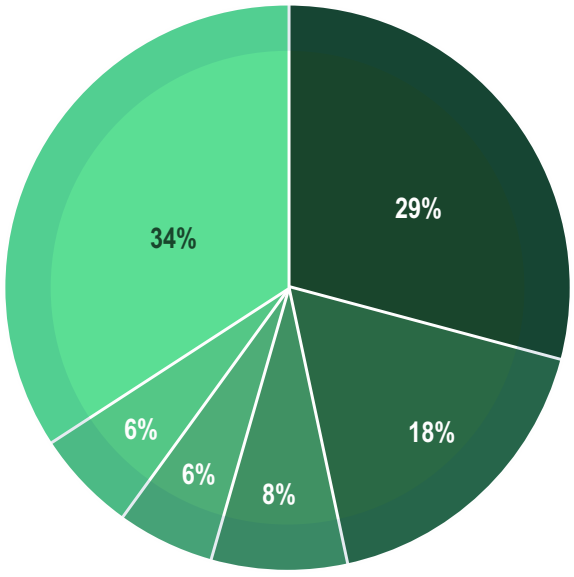
While it is useful to compare the global warming potential of insulation products that are suitable for the same application, the contribution of insulation to a building's entire embodied carbon budget is relatively small. Concrete and asphalt shingles typically account for up to half of a new home's embodied carbon.[8]

Top five embodied carbon emission sources over a 28 year useful life of a new production home in cold and warm climates, by material[9]

Top 5 Materials (Cold Climate)



Top 5 Materials (Warm Climate)



[7] "Beware the Hidden Ozone Depleter: Upstream Impacts of Blowing Agents," Habitable, 2018, https://habitablefuture.org/resources/beware-the-hidden-ozone-depleter-upstream-impacts-of-blowing-agents/.

[8] IBACOS, Inc., Building Technologies Office, Office of Energy Efficiency and Renewble Energy, U.S. Department of Energy, "Carbon Emissions in a Typical New Production Home: A Case Study," February 2023, p. 10, https://www.nrel.gov/docs/fy23osti/84227.pdf.

[9] Ibid

Increasing Insulation is One of The Best Ways to Reduce Building Carbon Emissions

Increasing air sealing and insulation in buildings is the best step toward decarbonizing new and existing residential, commercial, and industrial buildings. ICF's study shows that even with National Renewable Energy Laboratory (NREL) projected growth in renewable energy on the grid in the coming decades, more insulation still means higher carbon savings, even when insulating beyond model code levels.

Therefore, the decarbonization efforts should focus first adding as much insulation as possible to buildings. Investing in easily achievable insulation improvements in existing single-family homes, commercial buildings, and industrial facilities can produce long-term carbon emissions reductions. Nationally, the estimated carbon emissions reductions expected through renovating existing single-family homes with insulation are 10 billion tons of CO_2e over a 50-year period, the minimum useful life of building insulation.[10]

A Word About Cradle to Grave Environmental Impacts

While there is no widespread, publicly available data on the landfill considerations for every insulation type, it's critical to review the characteristics of insulation products when considering the potential landfill considerations of disposal. Fiberglass and mineral wool are non-biodegradable, considered to be low in toxicity.[11] Other insulation types, including cellulose and wood fiber insulation, are biodegradable and will decompose over time, releasing methane[12] that can have a high global warming potential if released into the atmosphere.[13]

Conclusion

As the research presented in this guide shows, not all insulation types are created equal when it comes to low-carbon building. Builders, architects, and policymakers should pay careful attention to claims made by insulation manufacturers and check them against the available data. Fiberglass insulation products have low embodied carbon and are cost effective. They are an excellent choice for meeting climate goals for residential, commercial, and industrial construction.

[10] ICF, August 25, 2022, "Insulation Industry Opportunity Study," https://www.insulationadvocacy.org/_files/ugd/bb658f_fa77af9cf52e4329bbcfd28cc1c20a35.pdf.

[11] Insulation Product Guidance," Informed, January 5, 2023, https://informed.habitablefuture.org/product-guidance/7-insulation.

[12] Xiaoming Want, et al., "Decomposition and carbon storage of selected paper products in laboratory-scale landfills," Science of the Total Environment 532, 2015, https://www.researchgate.net/publication/277784428_Decomposition_and_carbon_storage_of_selected_paper_products_in_laboratory-scale_landfills.

[13] Daniel H. Cushworth, et al., "Quantifying methane emissions from United States landfills," Science, Vol. 383, Issue 6690, March 28, 2024, pp. 1499-1504, https://www.science.org/doi/10.1126/science.adi7735.

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NAIMA is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. Its role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials. Through the Insulation Institute™, we leverage the collective insulation expertise of our organization and our members to empower homeowners and professionals to make informed insulation choices. Our mission is to enable a more comfortable, energy-efficient and sustainable future through insulation — and we are constantly working with building professionals, homeowners, government agencies, and public interest, energy and environmental groups to realize that vision.

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