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Embodied Carbon and Material Health in Insulation

Healthy Building Network
Perkins&Will

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Acknowledgments

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About the Authors

About Perkins&Will

Since 1935, we've believed that design has the power to make the world a better, more beautiful place. That's why clients and communities on nearly every continent partner with us to design healthy, happy places in which to live, learn, work, play, and heal. Fast Company has named us one of the World's Most Innovative Companies in Architecture three times, and in 2021, it added us to its list of Brands That Matter—a first for any architectural organization. We're passionate about human-centered design, and committed to creating a positive impact in people's lives through research, resilience, sustainability, diversity and inclusion, and well-being.
www.perkinswill.com

About Healthy Building Network

Since 2000, Healthy Building Network (HBN) has defined the leading edge of healthy building practices that increase transparency in the building products industry, reduce human exposure to hazardous chemicals, and create market incentives for healthier innovations in manufacturing. We are a team of researchers, engineers, scientists, building experts, and educators, and we pursue our mission on three fronts:

1. **Research and policy**
   Uncovering cutting-edge information about healthier products and health impacts;
2. **Data tools**
   Producing innovative software platforms that ensure product transparency and that catalog chemical hazards;
3. **Education and capacity building**
   Fostering others' capabilities to make informed decisions.

As a nonprofit organization, we do work that broadly benefits the public, especially children and the most marginalized communities, who suffer disproportionate health impacts from exposure to toxic chemicals. We work to reduce toxic chemical use, minimize hazards, and eliminate exposure for all.
www.healthybuilding.net

Insulation: Embodied Carbon and Material Health - Guidance to Optimize Both

Project teams want to design buildings that are healthy for people and the planet. But it is difficult to evaluate building products for both their embodied carbon and material health. To simplify this, Perkins&Will partnered with Healthy Building Network (HBN) to translate learnings from embodied carbon and material health assessment tools into actionable guidance for manufacturers, project teams, and green building programs. This guidance will empower you to optimize decisions and promote and select healthier, low-carbon products that advance a circular economy.

Intersection of Carbon and Material Health

Insulation is a unique product category that can reduce a building's operational carbon emissions by optimizing performance, lowering the energy required for heating and cooling. However, greenhouse gas emissions from insulation during the product life cycle (manufacturing, installation, end of life), called embodied carbon, often contribute to climate change. Insulation can also contain toxic chemicals that migrate into interior spaces, where occupants can be exposed by breathing the air or eating contaminated dust.[1] The chemicals of concern used to make insulation impact people and the planet negatively throughout the product life cycle.[2]

Research Results

Not all insulation product types can be used for all applications, nor are all insulation types exchangeable for one another. With this said, when we normalize by R value (a measure of how well insulation can resist heat flow), the biggest opportunities to reduce embodied carbon and prioritize material health in insulation come from choosing a product type with typically lower impacts for both.

Carbon/Health Alignment

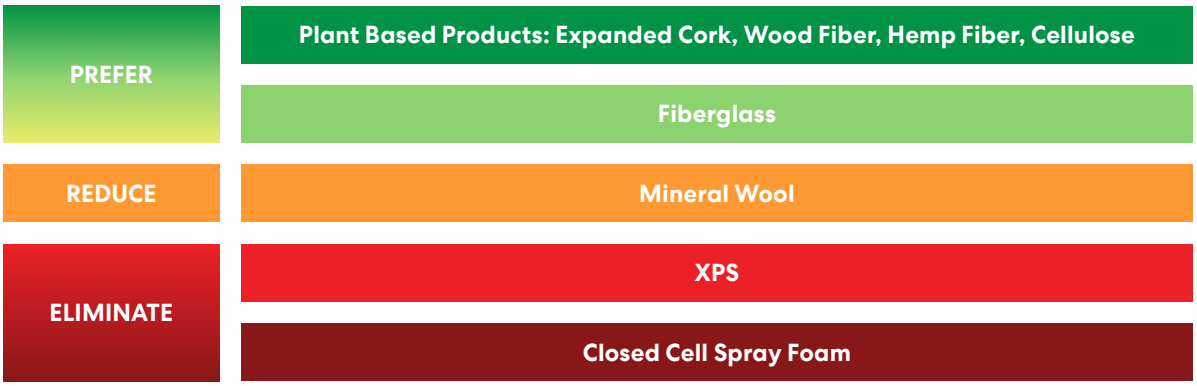


Figure 1. Summary guidance for selecting product types that are typically optimized for both embodied carbon and material health. For the full material health and embodied carbon guidance see Appendix B.

HBN and Perkins&Will hosted interviews with industry experts (manufacturers, industry associations and nonprofit entities), reviewed a sampling of environmental product declarations, and conducted a literature review of recently published industry guidance on both embodied carbon and material health in relation to insulation. This research validated that opportunities to reduce embodied carbon and improve material health with insulation can align (see Figure 1) and means that project teams can choose product types that optimize BOTH embodied carbon AND material health.

To choose insulation optimized for material health and carbon use the following guidance:

- **Select plant based materials.** Wood fiber, cellulose, and other plant based insulation materials are ranked well from both an embodied carbon and material health perspective.
- **Select fiberglass insulation.** If plant based materials are not a viable option, fiberglass insulation, without formaldehyde based binders or facers[3] ranked well.
- **Be careful when selecting mineral wool products.** Mineral wool insulation tends to be in the middle of both embodied carbon and material health guidance, with opportunities to improve on both metrics. Choose formaldehyde free, unfaced products manufactured using a more energy efficient furnace (such as an electric arc furnace) powered with renewable energy as an industry leading practice.[4]
- **Eliminate XPS and closed cell spray foam.** Plastic foam insulation that uses high global warming potential (GWP) blowing agents, such as extruded polystyrene (XPS) and closed cell spray foam are clearly the worst insulation materials by both metrics. These products use and release blowing agents with high global warming potential and hazardous chemicals such as persistent halogenated flame retardants (HFRs)[5] and asthmogenic isocyanates.[6]

Carbon/Health Conflicts

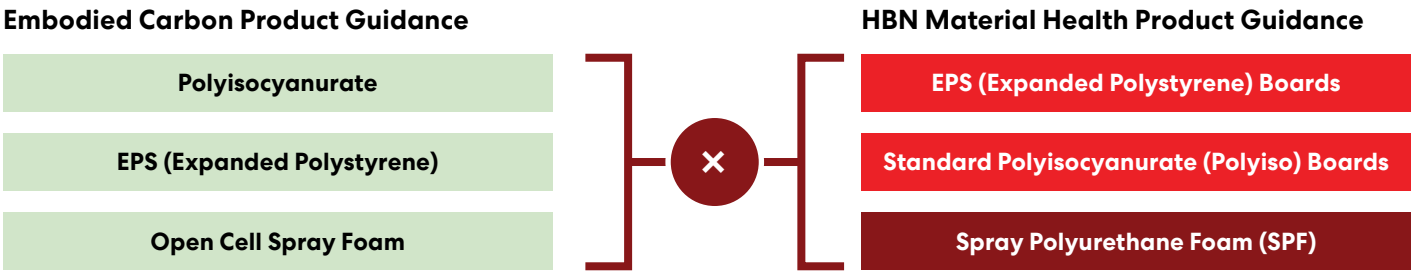


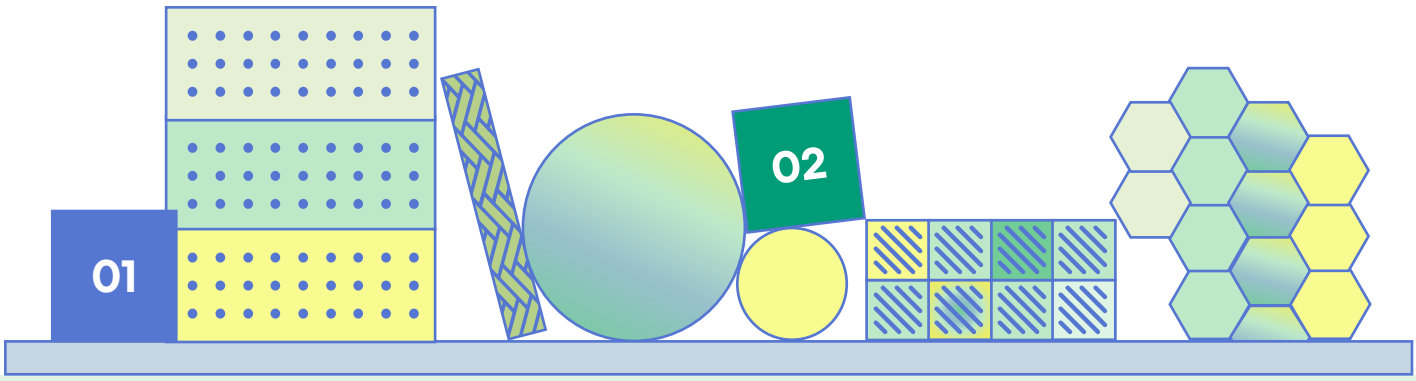
Figure 2. Example of product types that appear to be good choices from the embodied carbon guidance, but are worst in class based on the material health guidance. See Appendix B for the full material health and embodied carbon guidance.

The research also identified specific instances where steps to improve embodied carbon negatively impact material health or vice versa (see Figure 2). These conflicts highlight that it is critical to keep both methods of evaluation in mind when making material decisions.

To avoid insulation with hidden health impacts use the following guidance:

- **Reduce or eliminate plastic foam insulation.** Plastic foam insulation that uses lower GWP blowing agents such as polyisocyanurate boards, EPS and open cell spray foam ranks from middle to preferred from an embodied carbon lens, but ranks least-preferred in the context of material health, due to toxic chemicals, such as HFRs, isocyanates, and styrene[7], used throughout the product life cycle. If plastic board insulation is needed, polyisocyanurate boards without halogenated flame retardants are a less impactful option.
- **Consider innovative ways to reduce plastic foam insulation**, for example, by sandwiching polyiso boards with lower impact materials such as mineral wool or fiberglass boards.
- **Encourage innovation within the building industry** by issuing a call for novel low carbon, healthy insulation options that meets the performance needs (in particular moisture resistance and fire code requirements) not met by the existing preferred products.

General Steps for Designers, Architects and Building Owners to Select Low-Carbon, Safer Products



Step 01 ——
Choose product type

Prefer product types with typically safer materials (e.g. select product types that are green or yellow on HBN Informed Safe Material Guidance).

Prefer product types with typically lower embodied carbon (e.g. select product types using the Building Emissions Accounting for Materials (BEAM)[8]).

Step 02 ——
Choose specific manufacturer product

Prefer manufacturers with established take back programs who support transparency, extended producer responsibility (EPR), and are investing in recycling and reuse programs.

Prefer products with a Health Product Declaration (HPD) and/or Environmental Product Declaration (EPD).

Prefer products with HPDs that have all content characterized, screened, and identified to 100ppm and that have had their content verified by a third party.

Prefer products with product specific, Type III, third party verified EPDs (e.g. select products using the Embodied Carbon in Construction Calculator (EC3)[9] tool). Further, prefer EPDs with a robust interpretation section that includes specific embodied carbon hotspots identified, opportunities for improvement discussed, and progress towards those improvements disclosed within the EPD.

Appendix A

Opportunities for Additional Improvement Within Insulation Product Types

Fiberglass

LOWER-CARBON

- Reduce energy use at the fiberglass manufacturing site (e.g. by using recycled glass as a feedstock[10]). Note that low recycled glass supply is a limiting factor[11].
- Transition towards renewable energy sources.

LESS TOXIC CHEMICALS

- Prefer formaldehyde free binders. Consider the hazards and tradeoffs associated with the alternative binders and choose a fully disclosed safer alternative.
- Avoid products with carcinogenic dedusting oils, preferring safer alternatives, like vegetable oil.
- Avoid the use of facers, which can contain asphalt adhesives and HFRs.

Mineral Wool

LOWER-CARBON

- Reduce energy use at manufacturing site (e.g. prefer sites that use electric arc furnaces).
- Transition towards renewable energy sources.

LESS TOXIC CHEMICALS

- Prefer formaldehyde free binders.
- Prefer vegetable oil based dedusting oils.
- Avoid the use of facers.

Polyisocyanurate

LOWER-CARBON

- Reduce impacts from upstream suppliers (e.g. resins, blowing agents, and methylene diphenyl diisocyanate (MDI)).

LESS TOXIC CHEMICALS

- Prefer non-halogenated flame retardants.

Spray Polyurethane Foam (SPF)

LOWER-CARBON

- Eliminate use of hydrofluorocarbon (HFC) blowing agents.
- Reduce impacts from upstream suppliers. (e.g. resins, blowing agents, and MDI).

LESS TOXIC CHEMICALS

- Unfortunately there is a limited opportunity to improve spray foam insulation. MDI is a respiratory sensitizer and required chemistry for SPF. Instead, prefer mineral or plant based insulation.

Appendix B

Product Guidance for Material Health and Embodied Carbon

HBN Material Health Product Guidance

PREFER ⟶

- Expanded Cork Boards
- Blown-In Wood Fiber (Loose Fill and Dense Pack)
- Blown and Batt Sheep's Wool
- Hemp Fiber Batts
- Wood Fiber Batts and Boards
- Blown-in Fiberglass or Mineral Wool (Loose Fill, Dense Pack, and Spray-applied)
- Unfaced Fiberglass Batts
- Formaldehyde Free Mineral Wool Batts and Boards
- Blown-In Cellulose (Loose Fill)
- Unfaced Formaldehyde Free Fiberglass Boards
- Kraft-Faced Fiberglass Batts
- Cellulose/Cotton Batts
- Blown-in Cellulose (Dense pack and Wet-Blown)

⟵ REDUCE ⟶

- PSK- or FSK-Faced Fiberglass Batts
- Standard Mineral Wool Batts and Boards
- Standard Fiberglass Boards
- Halogen-Free Polyisocyanurate

⟵ ELIMINATE

- ASJ- or FSK-Faced Fiberglass Boards
- Expanded Polystyrene (EPS) Boards
- Standard Polyisocyanurate (Polyiso) Boards
- Extruded Polystyrene (XPS) Boards
- Spray Polyurethane Foam (SPF)

Embodied Carbon Product Guidance

- Wood Fiber
- Cellulose
- Fiberglass
- Polyisocyanurate
- EPS (Expanded Polystyrene)
- Open Cell Spray Foam
- Phenolic Foam
- Cellular Glass
- Mineral Wool
- Closed Cell Spray Foam, HFO
- Next Gen XPS, HFO/HFC
- Closed Cell Spray Foam, HFC
- XPS

←

HBN's Material Health Product Guidance uses a red-to-green ranking system to compare different types of products based on their hazardous content. It is informed by HBN's comprehensive research into the hazards associated with building products that may impact building occupants as well as fenceline communities and workers throughout the product's life cycle.[12]

↑

The Embodied Carbon Product Guidance is based on a 2022 report by Efficiency Vermont, which analyzed the embodied carbon impact for different insulation materials. This graph represents the product types with the lowest (best) to highest (worst) embodied carbon impacts.[13]

Efficiency Vermont summarized embodied carbon (100-year value) and ranked product types based on the average EPD-reported R-value per inch. The team defined embodied carbon impact as global warming potential impacts inclusive of A1–A3 plus A5, B1, and carbon storage.

Endnotes

1 Mitro, S. et al., "Consumer Product Chemicals in Indoor Dust: A Quantitative Meta-analysis of U.S. Studies," Environmental Science & Technology, 50, no. 19 (2016), pp. 10661–72, doi.org/10.1021/acs.est.6b02023.I. Broder, et al., "Comparison of health of occupants and characteristics of houses among control homes and homes insulated with urea formaldehyde foam. II. Initial health and house variables and exposure-response relationships," Environmental Research, 45, no. 2 (1988), pp. 156-178.

2 "Chemical and Environmental Justice Impacts in the Life Cycle of Building Insulation" HBN. 2022. https://healthybuilding.net/reports/24-chemical-and-environmental-justice-impacts-in-the-life-cycle-of-building-insulation

3 Formaldehyde based binders (e.g. urea-formaldehyde, phenol-formaldehyde and melamine-formaldehyde) can release formaldehyde during product use. Formaldehyde, CAS# 50-00-0, is listed as a carcinogen by numerous agencies including IARC.

4 Willms, T. et al. "Electric Arc Furnace - an alternative to the Cupula furnace for mineral wool production" International Glass Fiber Symposium. 2018.

5 Halogenated flame retardants (HFRs) can be persistent, bioaccumulative and toxic compounds (PBTs) and/or carcinogens. For example, Tris-(1,3-dichloro-2-propyl) phosphate (TDCPP), CAS# 13674-87-8, is listed as a carcinogen by California's Proposition 65 (prop 65). Hexabromocyclododecane (HBCD), CAS#s 25637-99-4 and 3194-55-6, is listed as PBTs by the EPA.

6 Isocyanates are considered respiratory sensitizers by Collaborative on Health and the Environment.

7 Styrene, CAS# 100-42-5, is a carcinogen per Prop 65, IARC, and U.S. NIH.

8 https://www.buildersforclimateaction.org/beam-estimator.html

9 https://buildingtransparency.org/ec3

10 Knauf Sustainable Minds Transparency Report for Ecobatt batts and rolls Cites that the use of recycled glass can lead to a 25% reduction in embodied carbon. https://res.cloudinary.com/knauf-insulation/image/upload/v1578825783/knauf%20insulation/batt%20insulation/ecobatt/standard/literature/knauf-ecobatt-epd.pdf

11 Based on conversations with various manufacturers.

12 https://healthybuilding.net/products/7-insulation

13 https://www.efficiencyvermont.com/Media/Default/docs/white-papers/The_High_GHG_Price_Tag_on_Residential_Building_Materials.pdf

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