Embodied Carbon and Material Health in Gypsum Drywall and Flooring

Healthy Building Network
Perkins&Will

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Acknowledgements

Thank you to the manufacturers interviewed for this case study including Mohawk, Shaw, and Tarkett, National Gypsum, US Gypsum, CertainTeed, and Georgia Pacific. Thank you to The Building Transparency and Building Product Ecosystems for sharing their knowledge and insights.

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.
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Executive Summary

Project teams want buildings that are healthy for people and the planet. Two sometimes competing criteria to evaluate the sustainability of building products are embodied carbon and material health.

For this case study, Perkins&Will partnered with Healthy Building Network to identify key drivers of embodied carbon and material health by looking at specific examples of product categories frequently specified in building projects. Using flooring and drywall as examples, this study identifies some examples of where paths toward low embodied carbon and safer materials align and where they conflict.

The goal of this case study is to translate the learning from embodied carbon assessment tools and material health assessment tools into actionable guidance for manufacturers, project teams, and green building programs that will allow them to optimize decisions and promote and select healthier, low-carbon products that advance a circular economy.

Results —— Gypsum Drywall

For gypsum drywall, the biggest opportunity to work toward lower-carbon is to reduce energy use at the drywall manufacturing site. The biggest opportunity to work toward material health for gypsum drywall is to reduce mercury releases from the drywall manufacturing facility by using natural gypsum instead of synthetic gypsum.

Results —— Flooring

The biggest opportunities to reduce embodied carbon and avoid chemicals of concern in flooring come from choosing a product type with typically lower impacts. For example, plant-derived bio-based flooring types such as linoleum, cork, or hardwood flooring tend to both be lower in embodied carbon and use safer materials than other flooring product types.

With that said, there are ways to improve within the carpet and resilient flooring product types. The biggest opportunity to reduce embodied carbon for carpet is to reduce impacts associated with the carpet fiber production, and for resilient flooring it is to increase the service life. The biggest opportunities to improve material health for both carpet and resilient flooring are to reduce manufacturing impacts associated with vinyl and polyurethane manufacturing and reduce legacy chemicals of concern in recycled content.

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Intersection of Carbon and Material Health

The results of this research validated that, for these two product categories, opportunities to improve embodied carbon and to improve material health, for the most part, align. This is an encouraging finding, in that project teams can choose product types that optimize BOTH embodied carbon AND material health.

On the other hand, the research also identified specific instances where steps to improve embodied carbon negatively impact material health or vice versa. These conflicts highlight the importance of keeping both methods of evaluating products in mind when making material choices.

Furthermore, this research points out the importance of considering different product types within a product category before considering different specific manufacturer products within a product type.

This case study was limited to two product categories, and other product categories will differ in the ways that embodied carbon and material health manifest. Nevertheless, this study shows that alignment between embodied carbon reduction and material health is possible. In the future, similar studies on other product categories would further help project teams choose product types that align with their sustainability goals.

We all have a role to play to protect human health and the environment. The material choices that projects teams make do not have to be either low embodied carbon or safer to human health. This paper recommends that teams choose product types that optimize BOTH embodied carbon AND material health wherever possible. While considerations including cost, performance, and aesthetics are also a fundamental part of material decisions, these steps provide actionable guidance to consider embodied carbon and material health as factors when making an overall product decision.

Furthermore, this research points out the importance of considering different product types within a product category before considering different specific manufacturer products within a product type.

Introduction

Our buildings and the products used to make them impact human health and the health of our planet in critical ways. Two sometimes competing methods to evaluate the sustainability of building products are embodied carbon and material health.

1. **Embodied carbon** refers to the GWP of carbon dioxide equivalent (CO_2e) emissions connected to the manufacturing and handling of a product. Lower embodied carbon values mean lower GWP associated with the raw material extraction, transportation, manufacturing, maintenance, and end of life for that product. CO_2e includes all greenhouse gas emissions and is often simply referred to as 'carbon'.
2. **Material health** examines hazardous chemicals used to make products and their reported potential to cause harm to humans and the environment. Safer materials are described as those that avoid hazardous chemicals and use fully disclosed, fully assessed, less hazardous alternatives during raw material extraction, manufacturing, installation, maintenance, and end of life.

While the two topics are both important, existing tools and resources make it difficult to evaluate the two together or to generate a single tool that works for all products. Different product categories (e.g., structural materials vs. paint) may require customized approaches to help with product selection. Projects teams may feel torn to focus on EITHER low embodied carbon OR safer materials. This research project explores both the adverse concessions that can inadvertently occur using this “either/or” approach and opportunities to select products that optimize BOTH embodied carbon AND material health.

Goal

Perkins&Will partnered with Healthy Building Network to identify the key drivers of embodied carbon and material health by looking at specific examples of product categories frequently specified in building projects.

Using flooring products and drywall products as examples, this case study aims to identify where paths toward low embodied carbon and safer materials align and where they conflict. The goal of this case study is to translate the learnings from embodied carbon assessment tools and material health assessment tools into actionable guidance for manufacturers, project teams, and green building programs that will allow them to optimize decisions and promote and select healthier, lower carbon products that advance a circular economy.

Introduction (continued)

Definitions

Climate justice
The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in the development, implementation, and enforcement of climate laws, regulations, and policies. Climate justice is a term that acknowledges and describes the disparities experienced by poor countries and communities that experience the negative impacts associated with climate change.[1]

CO2e/Carbon Dioxide equivalent
The number of metric tons of carbon dioxide emissions with the same Global Warming Potential (GWP) as one metric ton of another greenhouse gas. For example, methane has 25 times the GWP as carbon dioxide, therefore 1 metric ton of methane emissions is 25 metric tons CO2e for the purposes of impact reporting. CO2e includes all greenhouse gas emissions, including methane, chlorofluorocarbons, nitrous oxide, etc. but is often simply referred to as 'carbon'.

Embodied carbon
Refers to the GWP of carbon dioxide equivalent (CO2e) emissions connected to the manufacturing and handling of a product. Lower embodied carbon values mean lower GWP associated with the raw material extraction, transportation, manufacturing, maintenance, and end of life for that product.

Environmental Justice
The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in the development, implementation, and enforcement of environmental laws, regulations, and policies. Environmental Justice is realized when all people can realize their highest potential, without interruption by environmental racism or inequity. A community of Environmental Justice is one in which both cultural and biological diversity are respected, and where there is equal access to institutions and ample resources to grow and prosper.[2]

Environmental Product Declaration (EPD)
A standardized format for quantifying the environmental impact of a product or system, including GWP and other life cycle assessment (LCA) impact categories. EPDs include information on the impacts of raw material acquisition; energy use and efficiency; emissions to air, soil and water; and waste generation. EPDs may also include the content of materials and chemical substances. An EPD is a Type III Environmental Declaration that must:

- Be third-party verified by a Program Operator
- Conform to ISO 14025 and either EN 15804 or ISO 21930 guidelines
- Be developed based on LCAs that follow ISO 14040 and ISO 14040 and adhere to a Product Category Rule (PCR) that complies with ISO 14025.[3]

Operational carbon
Refers to the GWP of carbon dioxide equivalent (CO2e) emissions connected to the product's use (e.g., a building's energy consumption).

Product-Specific Type III EPD
Applies to a single product or product line from a single manufacturer, while an **Industry-Wide Type III EPD** uses industry averages to report impacts and is not specific to any one manufacturer or any one product.

Product category
The function of the product in the building. For example, flooring, insulation, or paint.

Product type
Variations in form or formulation of a product within a product category. For example, the flooring category includes types like linoleum, vinyl, and carpet; the insulation category includes types such as extruded polystyrene board (XPS), fiberglass batt, and spray polyurethane foam.

Specific manufacturer product A particular trade named manufacturer product. For example, Forbo Marmoleum Linoleum Flooring, Owens Corning Foamular XPS insulation, or CertainTeed Type C ⅝" Gypsum Board.

Materials Considered for this Case Study

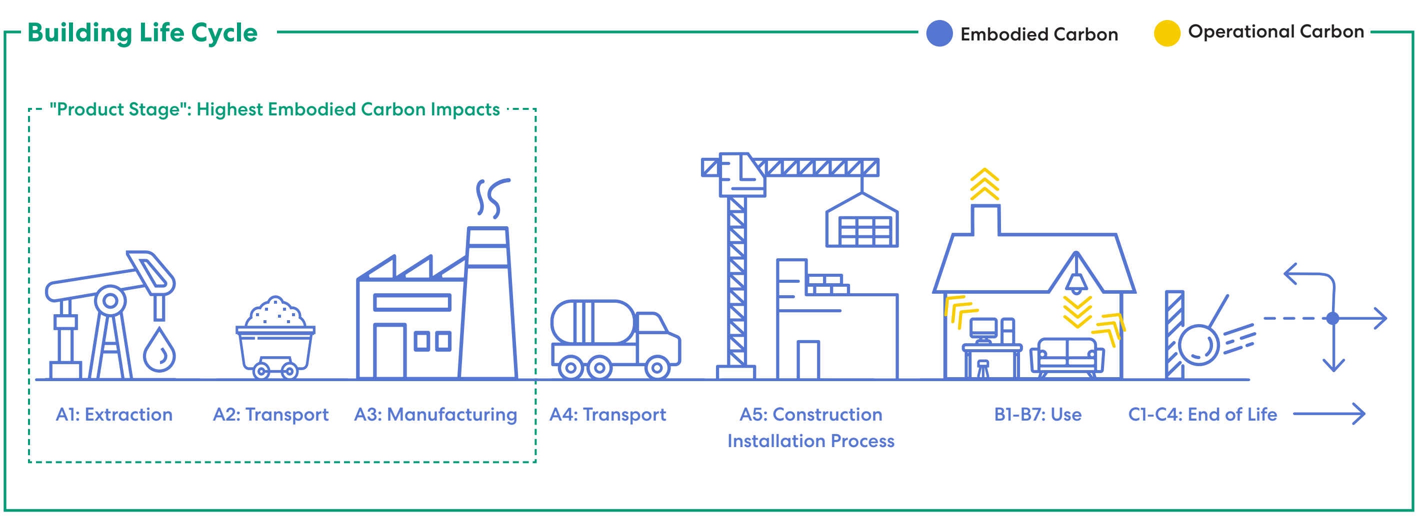
Flooring and drywall were selected as examples of product categories with the potential for hazardous chemical impacts that also contribute to the embodied carbon footprint of a building.

Drywall is a commonly used partition in buildings that can provide both fire protection and acoustical performance. Drywall use is prevalent in the U.S., where nearly 24 billion square feet of gypsum board is sold every year.[4] Flooring is another critical interior finish product in a building. Flooring materials provide aesthetic value and comfort in buildings. They can also provide acoustic value, insulation, and water resistance. In the United States alone, flooring amounted to over 23.5 billion square feet in coverage in 2019.[5] Taken together, the volume products of these two categories sold each year could completely cover the State of Rhode Island (and then some!).

Why Materials Matter — Lower Embodied Carbon

Human actions are the cause of the accelerated rate of climate change[6] and can be part of the solution to climate change. One significant contributor to global greenhouse gas (GHG) emissions is embodied carbon associated with building materials.[7] Embodied carbon encompasses GHG emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of materials. Embodied carbon is in contrast to operational carbon, which refers to the greenhouse gas emitted during a product's use (e.g., a building's energy consumption) (**see Figure 1**). Annually, the embodied carbon associated with building materials and construction accounts for 11% of global GHG emissions.[8] Significantly reducing the embodied carbon of building materials is critical to curbing global carbon emissions and further damage to our planet.

Figure 1: Embodied carbon impacts throughout the life cycle of a building[9]



Carbon emissions are driven by the materials used to construct buildings and how those materials are made. This matters for the communities impacted by changing global weather patterns, rising sea levels, warming of the ocean, and intensified weather events such as storms and wildfires. And it matters for the health of the warming planet.

The impacts of climate change are experienced differently by different populations. A recent United Nations (UN) publication describes that with respect to climate change "...the poorest countries are experiencing a disproportionate share of [climate related] damage and loss of life attributed to disasters".[10] Those hit hardest also have disproportionately low responsibility for GHG emissions. Climate justice is a term that acknowledges and describes these disparities.

How to Measure and Report Embodied Carbon

Environmental Product Declaration

One way of publicly reporting embodied carbon of a building product is with an environmental product declaration (EPD). An EPD is a standardized reporting method for the environmental impacts associated with a product.[11] An EPD can report many environmental impacts, one of which is the product's GWP, which reports the impacts in terms of the amount of carbon dioxide (or CO2 equivalent) emitted per unit of product (for example 1 m^2). EPDs that comply with the ISO 14040 standards are considered Type III EPDs, which, in addition to other requirements, means they have been third-party verified. EPDs can be manufacturer product-specific or generic, industry-wide documents. For the purposes of this study we have focused on Type III manufacturer product-specific EPDs. One source of published EPDs is the Embodied Carbon in Construction Calculator (EC3).

Embodied Carbon in Construction Calculator (EC3)

The EC3 tool is a service provided by Building Transparency, a nonprofit organization with a core mission to provide open-access data and tools across the building industry to address embodied carbon's role in climate change.[12] EC3 includes a free database of EPDs for building materials. Even manufacturer product-specific EPDs are developed to different levels of "certainty." Some are specific to one manufacturing plant location ("plant-specific") while others average across plants, and some address a product's whole life cycle, while others focus on manufacturing impacts. Some EPDs also count recycled and reused materials differently from others. A primary benefit of EC3 is that it translates each EPD in its catalog so that the manufacturing impacts of one material can be compared to those of another similar material, allowing teams to easily compare these impacts across similar products. Original EPDs are also available in the tool so that teams can refer back to source data. EC3 also includes a Building Planner for use in design and material procurement. This tool allows project teams to better understand a project's overall embodied carbon emissions, set limits and goals for reduction, prioritize specification and procurement of low carbon products, and review a product's performance against a baseline (when available). The tool serves as a database of both product-specific and industry EPDs, where standard ranges of embodied carbon emissions, from conservative to achievable, are listed by product type. The EC3 tool's intent is to incentivize manufacturers to invest in disclosure, transparency, and innovations that reduce their product's embodied carbon emissions.

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Why Materials Matter —— Safer Materials

Our buildings impact our health and productivity, and what we put in our buildings matters. It matters for our health and the health of our children. It matters for the people and places throughout the manufacturing supply chain and construction trades interacting with materials. And it matters for the health of the planet.

We spend 90% of our time indoors, and hundreds of industrial chemicals are found in our indoor spaces—in the dust, in the air we breathe, and also in our bodies.[13] Most indoor pollution comes from sources inside the building.[14]

One source of chemicals of concern is from building products. Researchers and scientists have linked exposure to toxic chemicals to harmful human health impacts,[15] yet few of the large number of chemicals in use have been adequately tested for human health impacts. Significantly reducing toxic chemical use is an essential action towards helping to strive for a healthy building.

Like carbon emissions, the health impact of building materials is not limited to their time in use in the building. In fact, the biggest impacts often occur during manufacturing, installation, and at the product's end of life. People living in close proximity to industrial facilities experience persistently worse air quality than average. Exposure to industrial pollutants disproportionately impacts people of color to the point where the biggest indicator of a person's health is where they live, work, and play.[16] Environmental justice is realized when all people can realize their highest potential, without interruption by environmental racism or inequity.

How to Measure and Report Material Health

Health Product Declaration

One way of publicly reporting chemical content associated with building products is through a Health Product Declaration (HPD). The HPD Open Standard provides a framework for product manufacturers and their ingredient suppliers to report and disclose information about the product, product content, and associated health information. The Standard is governed by the HPD Collaborative, a nonprofit member organization. Published HPDs compliant with the HPD Open Standard can be found in the HPD Public Repository.

Researchers and scientists have linked exposure to toxic chemicals to harmful human health impacts, yet few of the large number of chemicals in use have been adequately tested for human health impacts.

Methods

Embodied Carbon Research Methods

To identify the key drivers of embodied carbon and the key opportunities to reduce embodied carbon for each product type, the following resources were used:

EPDs

The authors reviewed a minimum of 10 Type III manufacturer product-specific EPDs covering products from at least four manufacturers for each product type. The authors did not include industry-wide EPDs in the analysis. The authors recorded where available:

- drivers of embodied carbon,
- assumed recycled content,
- assumed end of life,
- actions taken to reduce embodied carbon, and
- further opportunities identified to reduce embodied carbon.

Interviews

The authors conducted a minimum of three manufacturer interviews for each product type with the goal of confirming key drivers of embodied carbon, understanding key opportunities to reduce embodied carbon, and identifying barriers to those opportunities. The flooring manufacturers interviewed for this case study included Mohawk, Shaw, and Tarkett, who all produce both resilient flooring and carpet. The drywall manufacturers interviewed included National Gypsum, US Gypsum, CertainTeed, and Georgia Pacific.

The authors also interviewed the Building Transparency staff and Building Product Ecosystems, a company that works with building owners to optimize material resource cycles.

Literature Review

The authors reviewed existing literature and data compilations such as Building Transparency's Embodied Carbon in Construction Calculator (EC3) and Carbon Smart Materials Palette.

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Material Health Research Methods

HBN Common Product Research

Systematic product type research was conducted using information from HPDs, other product content disclosures, safety data sheets, product data sheets, patents, industry literature, and product testing. These data were compiled and the chemicals and materials were organized by the different functions (for example, stain treatment, fiber, dye, etc.) needed in a product type. Then the chemical or material most commonly used for that function was identified as "common content." The resulting data record, called a "Common Product," is not specific to any one manufacturer, but rather lists the substances that are most commonly present in a given product type. Since 2015, HBN has generated over 200 Common Product records. The Common Product methodology and product records are available on the Pharos database.[17, 18]

HBN Hazard Spectrums

An inherently safer building material is one that minimizes the use of hazardous chemicals during the manufacture, installation, and use of the product. HBN's Product Hazard Spectrum tools use a red (avoid) to green (prefer) ranking system to compare material types within a product category based on their common content. They are informed by HBN's Common Product research and the chemical hazards associated with building materials that may impact building occupants, fenceline communities (neighborhoods next to manufacturing facilities), and workers throughout the product's life cycle.

As an example, the Flooring Products Hazard Spectrum encompasses a wide variety of flooring options, including wood, linoleum, rubber, carpet, and vinyl flooring (**see Figure 2**). By selecting product types that are green, light green, or yellow on the hazard spectrum—and avoiding those in red and orange levels—one can prefer product types that commonly use safer chemistry during the product life cycle.

The Hazard Spectrums are a screening-level tool intended to be used early in the design process to select typically safer types of products. When selecting a specific manufacturer product, HBN further recommends selecting products with a public disclosure of product content, such as an HPD or International Living Future Institute (IFLI) Declare label.

Methods (continued)

By selecting product types that are green, light green, or yellow on the hazard spectrum—and avoiding those in red and orange levels—one can prefer product types that commonly use safer chemistry during the product life cycle.

Figure 2. HBN Flooring Products Hazard Spectrum

- Linoleum
- Solid Wood Floors (pre-finished)
- Concrete (no finish/accessories or only densifier without PFAS)
- Ceramic Tiles (made in the USA/lead-free with no CRT content)
- Solid Wood Floors (site-finished)
- Cork Floors (pre-finished)
- PVC-free Resilient Flooring
- Engineered Wood Floors (pre-finished)
- Rubber or Rubber/Cork Floors (made without tire-derived crumb rubber)
- Laminate
- Carpet (with no fly ash, no vinyl or polyurethane backing, and no PFAS)
- Polyurethane (PU) Resilient Flooring
- Engineered Wood Floors (site-finished)
- Vinyl Floors (no phthalates or hazardous recycled content)
- Ceramic Tiles (not made in the USA/presence of lead is unknown/CRT tiles)
- Concrete (with sealers or with densifiers/coatings containing PFAS)
- Rubber or Rubber/Cork Floors (made with tire-derived crumb rubber)
- Carpet (containing fly ash, vinyl or polyurethane backing, and PFAS)
- Vinyl Floors (containing phthalates, hazardous stabilizers, and hazardous recycled content)

Results —— Gypsum Drywall

Embodied Carbon Results

All EPDs reviewed for drywall concluded that the majority of the carbon emissions are from the "Product Stage," which includes raw material supply, transportation to the manufacturing site, and manufacturing impacts. For drywall the majority of the carbon emissions are from the energy used at the product manufacturing site.[19] This means that the greatest opportunities to reduce embodied carbon for those products is to address the way they are made.

Embodied Carbon Drivers for Gypsum Drywall

Gypsum can be natural (mined from the earth) or synthetic (a byproduct from coal-fired power plants). Synthetic gypsum, also known as FGD gypsum, is waste generated from pollution control devices at coal-fired power plants. Flue-gas desulfurization (FGD) units generate FGD waste, which is further processed into FGD gypsum.[21]

Gypsum drywall is produced by first dehydrating incoming gypsum. The resulting "calcined" gypsum is then mixed with water and additives and spread between two layers of facing material, typically paper, then rolled and dried into the final board product.

Within this Product Stage, raw materials and transport contributed a relatively small amount to the total embodied carbon of drywall. The use of FGD gypsum is considered "burden free" per the EPDs reviewed, meaning the carbon releases associated with burning coal (to generate the coal ash that is then further processed to create FGD gypsum) are not included in the embodied carbon values for drywall.[22] However, even mining of natural gypsum, which is not "burden free," contributes only a small percentage of the total embodied carbon for drywall.

The majority of the embodied carbon for drywall is associated with the manufacturing process, namely, the heat required for drying and energy required for rolling and shaping the drywall during product manufacturing.

Based on the cited references[20], the main drivers for embodied carbon for drywall are:

<10%	<10%	~80%
Raw materials: Gypsum mining	**Transportation**	**Manufacturing: Energy at the manufacturing site**

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Opportunities to Improve Embodied Carbon for Gypsum Drywall

Using the cited references, a large list of opportunities to reduce embodied carbon in drywall was generated and the most impactful opportunities were identified. These top opportunities focus on reducing the energy impacts during manufacturing. They include:

1 —— Implement efficient moisture control at manufacturing.
Thorough dehydration of incoming gypsum raw material is required to decrystallize the calcium sulfate. This "calcined" material is rehydrated into a slurry and formed into boards that are then dried to form the final product. Both drying stages have opportunities for improved efficiency. Additives used during the slurry phase can reduce the total amount of water needed and therefore reduce the energy needed to dry the final boards.[23]

2 —— Use renewable energy in the manufacturing process.
Electrification of the manufacturing process and using renewable energy sources could reduce the overall embodied carbon footprint.

3 —— Dematerialize (use thinner/lighter boards).
Lighter or thinner boards require less gypsum slurry and therefore less energy to dry. Limitations of dematerialization include a minimum thickness or mass to meet fire code requirements (typically a minimum of ¾ inch), acoustics, and strength.

4 —— Choose a product with a publicly disclosed EPD.
Prefer product-specific and plant-specific Type III EPDs. While having an EPD in and of itself does not mean that a product is optimized for embodied carbon, it is a good first step to understand the impacts associated with a product and where there are opportunities to improve.

Material Health Results

The biggest opportunities to avoid chemicals of concern in gypsum drywall come from choosing a product type with typically lower chemicals of concern. The HBN Drywall Hazard Spectrum (see Figure 3) is one tool that compares generic product types based on material health impacts.

Material Health Drivers for Gypsum Drywall

Drywall is made up of a mineral core of gypsum and additives, sandwiched between facing materials. Fire-resistant panels, like Type X and Type C, and mold- or moisture-resistant panels contain additional additives like glass fibers and antimicrobials. The potential for toxic additives, along with mercury releases during manufacturing, are two main drivers for material health in drywall.

Mercury releases from manufacturing sites. FGD gypsum (gypsum from coal-fired power plants) can contain hazardous heavy metals such as mercury.[25] Mercury is highly toxic, and because it is persistent in the environment, it can travel large distances and have far reaching impacts on human and environmental health.[26] Mercury is released from drywall manufacturing facilities during the dehydrating/calcining process and/or the board drying process.[25] According to data reported to the U.S. Environmental Protection Agency (EPA) by drywall manufacturers,[27] mercury emissions from drywall manufacturing facilities increase as more FGD gypsum is used.[28] While this does not necessarily translate into more mercury in the drywall itself as delivered to the project site, it does mean more mercury released in the communities surrounding the drywall manufacturing facilities.

Toxic additives. Additives such as antimicrobials, dispersants, flow-aids, and strengtheners can be hazardous to humans or the environment. For example, sodium pyrithione is commonly used as an antimicrobial in mold-resistant drywall and is harmful if swallowed or inhaled, toxic in contact with skin, and very toxic to aquatic life with long-lasting effects.[29] For another example, boric acid is commonly used as a strengthener in drywall and may damage fertility or the unborn child per the EU.[30]

Figure 3. HBN Hazard Spectrum for Drywall

See **HBN's Product Page for the full Drywall Products Hazard Spectrum** with more data, details, logic, sources, and guidance.[24]

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Opportunities to Improve Material Health for Gypsum Drywall

Using the cited references, including the Drywall Hazard Spectrum (see Figure 3), a list of opportunities to improve material health for drywall was generated and the most impactful and actionable opportunities were identified. These top opportunities all focus on reducing avoidable hazardous chemicals. They include:

1 —— Prefer natural gypsum products.
Natural gypsum drywall is yellow or green (which means "preferred" over product types that are red and orange) on the Drywall Hazard Spectrum. Prefer drywall products with the lowest amount of FGD gypsum (also known as synthetic or pre-consumer recycled content) available. If you must use products made with FGD gypsum, ask manufacturers to publicly disclose how they monitor and limit mercury content and emissions.

2 —— Avoid mold-resistant drywall where not needed.
Mold-resistant drywall may be deemed necessary in certain applications, such as areas that experience periodic elevated humidity like bathrooms. Because these products contain added antimicrobials that may be hazardous, avoid using them where they are not needed, like in spaces with little moisture concerns.

3 —— Choose a product with a publicly disclosed content inventory such as an HPD or Declare.
Further, prefer products with public HPDs that have all contents characterized, screened, and identified to 100 ppm (parts per million) and have had their contents verified by a third party. While having an HPD or Declare label in and of itself does not mean that the product uses safer materials, public ingredient disclosure is an important first step to improving material health.

Intersection of Material Health and Embodied Carbon —— Gypsum Drywall

As a high volume building material, drywall represents an opportunity for the construction industry to reduce negative human and environmental impacts by making better-informed decisions.

The results of this research validated that the choices made to improve embodied carbon and to improve material health, for the most part, align. This is an encouraging finding for communicating that project teams can choose product types that optimize BOTH embodied carbon AND material health.

On the other hand, the research also identified specific instances where steps to improve embodied carbon negatively impact material health or vice versa. These conflicts highlight the importance of keeping both methods of evaluating products in mind when making material choices.

Alignment ——

The opportunities to improve embodied carbon and material health for gypsum drywall are largely complementary. For example:

Use renewable energy and use natural gypsum.

In the U.S. and many other parts of the world, the use of coal for power is decreasing as the use of renewable sources of energy (solar, wind, biomass, hydroelectric, geothermal) is increasing.[31] The result is that the associated carbon impact per unit of electric power has decreased generally.[32] As coal-fired power plants reduce capacity or shut down, the drywall industry moves away from mercury-containing FGD gypsum and towards natural gypsum.[33, 34]

Use thinner or lighter boards and reduce toxic additives.

Thinner or lighter boards use less energy to produce. Lighter boards use less materials generally, which will translate to less additives overall including less additives of concern. Dematerialization is limited by fire-rating and acoustics performance requirements.

Conflict——

Opportunities to improve embodied carbon may conflict with material health optimization in the following ways.

Increase moisture control and reduce toxic additives.

Additives can be used during manufacturing to help the gypsum slurry flow better with less water. Less water added during manufacturing means less energy needed to dry the boards, which in turn can lower the embodied carbon for the product. However, these additives can have hazards associated with them as discussed above. Manufacturers should fully disclose and fully assess additives and choose the least hazardous options available.

Results —— Flooring

Embodied Carbon Results

Similar to drywall, all EPDs reviewed for flooring concluded that the majority of the carbon emissions are from the "Product Stage," which includes raw material supply, transportation to the manufacturing site, and manufacturing impacts. Unlike drywall, flooring products' embodied carbon impacts are mostly associated with the raw material supply. This means that the greatest opportunities to reduce embodied carbon for those products is to address the impacts associated with those raw materials.

The biggest opportunities to reduce embodied carbon in flooring come from choosing a different product type that uses raw materials with typically lower embodied carbon and longer service life within the flooring category. A recent review of available flooring product type comparisons summarized the findings into a simple table ranking product types from greatest impacts to least impact (See Table 1). The report considered the impacts associated with a set area over the course of a 75-year building life. Carpet was consistently the most impactful product type due in part to its short service life (estimated by the paper's authors to be 11 years). Plant-based flooring products, such as wood and natural cork, were consistently the least impactful.

Embodied Carbon —— Flooring

Table 1. Ranking of Various Floor Covering Materials by Relative Global Warming Potential[39]

RELATIVE IMPACT GWP	FLOORING TYPE
	Wood
Least (prefer)	Natural cork
	Natural cork floating floor
	Linoleum
Intermediate (use caution)	Virgin vinyl composite tile
	Ceramic tile
	Terrazzo
Greatest (avoid)	Composite marble tile
	Virgin nylon carpet
	Wool carpet*

There are additional flooring product types available on the market that are not represented in this table.

* See clarification on page 36.

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Embodied Carbon Drivers for Carpet

While the biggest opportunity to reduce embodied carbon for flooring is to move away from carpet, there are ways to improve within the carpet product type. Many of the EPDs reviewed for carpet cited raw material production as the biggest contributor to life cycle impacts, and specifically nylon carpet fiber as the largest raw material impact. Beyond that observation, few of the EPDs indicated where the biggest opportunities for improvement lay.

Based on the cited references[35] the main drivers of embodied carbon for carpet are:

~70%

Raw materials: Carpet fiber (usually virgin nylon) and raw material production

~20%

Raw materials: Backing raw material production

~10%

Manufacturing: Assembly of the carpet product

Opportunities to Improve Embodied Carbon for Carpet

Using the cited references, a list of opportunities to reduce embodied carbon in carpet was generated and the most impactful opportunities were identified. These top opportunities both focus on reducing the amount of carpet fiber, namely virgin nylon, needed to produce new carpet. They include:

1 —— Design circular products.

Circular design can, in theory, reduce the need for virgin nylon. While circular design is a key opportunity, it is important to recognize that right now, plastic building materials are rarely recycled and even more rarely recycled into new building materials.[36] Without investments towards making plastics a circular material, these recycled materials are destined to end up in landfills or burned **(see Figure 4)**. Such investments include, but are not limited to: universal take-back programs, design for deconstruction, minimal use of chemicals of concern, and materials transparency.

2 —— Dematerialize.

Use low-pile products (shorter nylon face fiber) to reduce the amount of nylon needed per square foot of carpeting. This dematerialization should not reduce the service life of the carpet to a point where it requires replacement more frequently than standard carpet (every 8-11 years). Further, use carpet tile instead of broadloom (sheet carpeting) to reduce wasted material during manufacture, installation, and maintenance.[37]

3 —— Choose a product with a publicly disclosed EPD.

Prefer product-specific and plant-specific EPDs. While having an EPD in and of itself does not mean that a product is optimized for embodied carbon, it is a good first step to understand the impacts associated with a product and where there are opportunities to improve.

Legacy chemicals of concern and the circular economy.

Using products that contain recycled content can be a great way to reduce environmental impacts and support a circular economy by keeping still-useful materials out of landfills and avoiding the impacts of manufacturing virgin materials. While some recycled feedstocks, such as sawdust and glass containers, can be safely recycled into new products, others contain legacy contaminants that can lead to toxic exposures when used in new products. For example, 2015 testing of a range of vinyl floors found high levels of toxic lead and cadmium from recycled content in the inner layers of the floors.[38]

Removing toxic chemicals from new products makes a commercial afterlife possible, supports a safe and circular economy, and minimizes negative human health impacts. Using materials that are recoverable at the end of their life and building infrastructure to reuse or recycle them will lessen future impacts. Fully and transparently documenting product contents now also supports future recycling by identifying materials that may later be determined to be toxic.

Embodied Carbon —— Resilient Flooring

Embodied Carbon Drivers for Resilient Flooring

Similar to carpet, the resilient flooring EPDs reviewed concluded that the majority of the carbon emissions are from the "Product Stage," which includes raw material supply, transportation of those raw materials to the manufacturing site, and manufacturing. Most of the resilient flooring EPDs reviewed did not contain an interpretation on where in the supply chain the impacts were coming from nor where the biggest opportunities for improvement lay.

The manufacturers interviewed added that there is not as much embodied carbon information available on resilient flooring compared to carpet. Furthermore, the products in the resilient flooring category vary widely by resin type, thickness, layers, and service life, whereas carpet products vary less.

Based on the cited references[40] that did contain this interpretation, the main drivers of embodied carbon for resilient flooring are:

Raw Material:
Resin (typically vinyl) raw material production

Raw Material:
Flame retardant raw material production

Product Use:
Service life (how long the product is used)

Specific percentages associated with each driver were not available within the references cited.

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Opportunities to Improve Embodied Carbon for Resilient Flooring

Using the cited references, a list of opportunities to reduce embodied carbon in resilient flooring was generated and the most impactful opportunities were identified. These top opportunities all focus on reducing the amount of new/virgin materials. They include:

1 —— Extend Service Life.
Use flooring that has a long service life, that is aesthetically versatile, and that can be repaired or refinished to extend the service life of the product and minimize replacement. Product life cited for resilient flooring in the EPDs reviewed ranged from 5-75 years, and use data shows resilient flooring is replaced every 10-40 years.[35, 40] The actual flooring length of use will have a big influence on the product's total embodied carbon. Avoid replacing flooring that hasn't reached its end of life, or if it must be replaced, recover the material for reuse.

2 —— Dematerialize.
Use flooring options that use less material per square foot. For example, click tiles tend to be thicker and use more material than flooring with a peel & stick adhesive. However, dematerialization should not be at the expense of performance or service life.

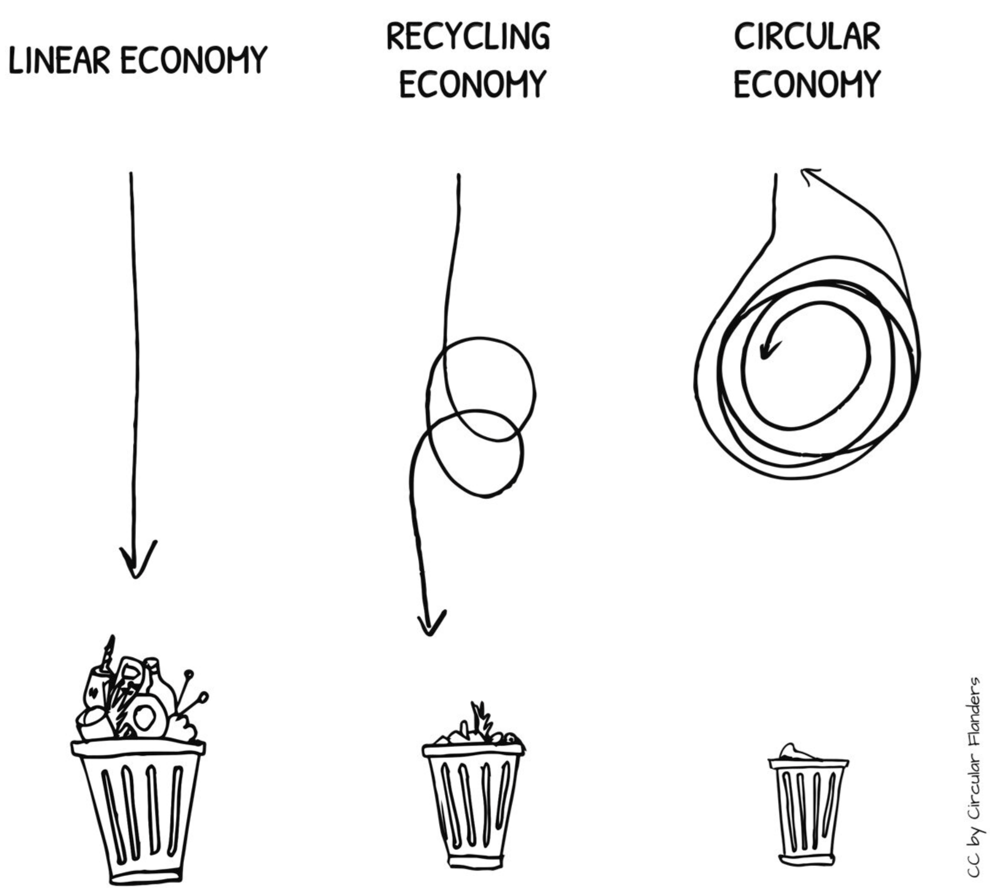
3 —— Design circular products.
While circular design is a key opportunity, it is important to recognize that right now, plastic building materials are rarely recycled and even more rarely recycled into new building materials.[37] Without investments towards making plastics a circular material, these recycled materials are destined to end up in landfills or burned (**see Figure 4**). Such investments include, but are not limited to: universal take-back programs, design for deconstruction, minimal use of chemicals of concern, and materials transparency.

4 —— Choose a product with a publicly disclosed EPD.
Prefer product-specific and plant-specific Type III EPDs. While having an EPD in and of itself does not mean that a product is optimized for embodied carbon, it is a good first step to understand the impacts associated with a product and where there are opportunities to improve.

Recycling and the Circular Economy—— a Cautionary Tale

Many manufacturers offer take-back programs for flooring at the end of its service life, however, often the flooring is sent to power plants as a fuel source as opposed to being recycled into new products. To build the demand for a circular economy it is important to ask the details of each providers take-back program and the amount of used product they recycle into new product compared to the virgin material produced. See the Interventions section for more information about policy tools to support a circular economy.

Figure 4. The difference between recycling and circularity.[41]



Material Health Results

The biggest opportunities to avoid chemicals of concern in flooring come from choosing a product type with typically fewer chemicals of concern. The HBN Flooring Hazard Spectrum (see Figure 2) is one tool that compares generic product types based on material health impacts. Selecting a product that is yellow or above in the Hazard Spectrum, such as wood or linoleum, will minimize the use of hazardous chemicals versus an orange or red product, such as vinyl and carpet, which are ranked at the bottom as product types to avoid.

See HBN's Product Guidance for the full Flooring Products Hazard Spectrum with more data, details, logic, sources, and guidance.[42]

Material Health —— Carpet

Material Health Drivers for Carpet

Carpeting is variable and can be made in many combinations of backings, face fibers, and surface treatments. The main material health concerns in carpet include fly ash, vinyl and polyurethane backings, and per- and polyfluoroalkyl substances (PFAS).

Toxic heavy metals in post-industrial recycled content such as fly ash. Fly ash is a byproduct from coal-fired power plants that is used as a filler in carpet tile backing and contains heavy metal contaminants.[43, 44] These contaminants include lead, mercury, arsenic, and cadmium, all of which have serious human health concerns.[45] Alternative fillers include calcium carbonate and ground, recycled post-consumer container glass, which are becoming more common and are typically safer materials.

Manufacturing releases from vinyl and polyurethane production. Vinyl (aka polyvinyl chloride or PVC) and polyurethane are commonly used as backing materials for carpet. Both vinyl and polyurethane use mercury, asbestos, and PFAS in the production process.[46] Mercury is a developmental toxicant per California's Office and Environmental Health Assessment (via a regulation known as Proposition 65).[47] Asbestos is a carcinogen per Proposition 65. PFAS are persistent chemicals, which means they do not break down easily in the environment. Alternative backings like polyolefin typically contain fewer additives and less hazardous additives.[48]

Per- and polyfluoroalkyl substances (PFAS). PFAS, used in stain-repellent treatments for carpet fibers, are a high priority to avoid. As stated above, PFAS are highly persistent chemicals that can also be toxic. They are sometimes called "forever chemicals." Alternative treatments are becoming available but, greater transparency about their chemical identities and hazards is still needed.

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Opportunities to Improve Material Health for Carpet

The biggest opportunities to avoid chemicals of concern in flooring come from choosing a product type with typically fewer chemicals of concern. These are described in detail in the Flooring Hazard Spectrum (see Figure 2). For example, choosing linoleum or wood (both green, or preferred, on the Flooring Hazard Spectrum) over carpet or vinyl flooring avoids both PFAS and PVC as well as other chemicals of highest concern.

However, within carpet products, there are some opportunities to improve material health.

1 —— Prefer carpet with no PFAS, no fly ash, and no vinyl or polyurethane backings.
This type of carpet is orange (improved over product types in red, but still avoid when possible) on the Flooring Hazard Spectrum (**see Figure 2**).

2 —— Prefer carpet with recycled content that is from known sources and has been tested to avoid common contaminants of concern.
Common chemicals of concern found in post-consumer recycled nylon can be found in the Pharos database.[49] Prefer products that have been tested for these chemicals and have below detectable levels or levels below what would be found in virgin resin content.

3 —— Choose a product with a publicly disclosed content inventory such as an HPD or Declare.
Further, prefer products with public HPDs that have all contents characterized, screened, and identified to 100 ppm (parts per million) and have had their contents verified by a third party. While having an HPD or Declare label in and of itself does not mean that the product uses safer materials, public ingredient disclosure is an important first step to improving material health.

Material Health —— Resilient Flooring

Material Health Drivers for Resilient Flooring

Resilient flooring is a durable flooring that includes several unique product types such as vinyl, linoleum, cork, rubber, wood plastic composite (WPC), and non-pvc resilient. Vinyl flooring is the most common resilient flooring option used today and is the focus of this analysis. Resilient flooring can be homogeneous (uses the same material throughout the flooring) or heterogeneous (composed of different layers of different materials). The main drivers for material health include the base resin and legacy chemicals of concern in recycled materials.

Manufacturing releases from vinyl (PVC) manufacturing. The concerns with vinyl manufacturing cited under carpet apply for resilient flooring as well. Polyvinyl chloride (PVC) is the most common resin used in resilient flooring and is always present in vinyl sheet, vinyl tile, and luxury vinyl tile (LVT). It is also commonly used in WPC and may be used in cork click-tile flooring.[50]

Legacy chemicals of concern in recycled materials. Before an industry-wide voluntary phase-out in 2018, vinyl flooring commonly contained orthophthalates (often referred to as phthalates), which can be developmental toxicants per the National Toxicology Program (NTP).[51] Recycled vinyl can come from multiple sources and can contain orthophthalates as well as persistent, bioaccumulative, and toxic compounds including lead and arsenic (**see "Legacy Chemicals of Concern and the Circular Economy" text box**).

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Opportunities to Improve Material Health for Resilient Flooring

As stated above, the biggest opportunities to avoid chemicals of concern in flooring come from choosing a different product type with typically fewer chemicals of concern. These are described in detail in the Flooring Hazard Spectrum (see Figure 2). For example, linoleum is a resilient flooring product type that is green (preferred) on the Flooring Hazard Spectrum. Some of these options are other types of resilient flooring.

However, within resilient flooring, there are some opportunities to improve material health.

1 —— Prefer bio-based flooring options.
Plant bio-based products tend to be the most preferred products on the Flooring Hazard Spectrum. Examples include linoleum and cork (without PVC core).

2 —— Choose a non-vinyl resilient flooring option.
There are many options for non-PVC resilient flooring. These include linoleum, cork (without PVC core), polyethylene, polypropylene, ethylene vinyl acetate, and polyester products. While these products are not free of manufacturing concerns, they typically use fewer chemicals of concern during raw materials production than PVC.[48] Additionally, these other product types do not require as many additives as PVC, such as stabilizers and plasticizers. Fewer additives means fewer opportunities to introduce chemicals of concern and increased recycling value of the product at the end of life.

3 —— If a PVC-based flooring is needed, choose a product with no orthophthalates and with vinyl content with recycled content that is from known sources and has been tested for common contaminants of concern.
Common chemicals of concern found in post-consumer PVC are available in the Pharos database.[52] Prefer products that have been tested for these chemicals and have below detectable levels or levels below what would be found in virgin resin content for these chemicals.

4——Choose a product with a publicly disclosed content inventory such as an HPD or Declare.
Further, prefer products with public HPDs that have all contents characterized, screened, and identified to 100 ppm (parts per million) and have had their contents verified by a third party. While having an HPD or Declare label in and of itself does not mean that the product uses safer materials, public ingredient disclosure is an important first step to improving material health.

Intersection of Material Health and Embodied Carbon —— Flooring

As a high volume building material, flooring represents an opportunity for the construction industry to reduce negative human and environmental impacts by making better-informed decisions.

The results of this research validated that the choices made to improve embodied carbon and to improve material health, for the most part, align. This is an encouraging finding for communicating that project teams can choose product types that optimize BOTH embodied carbon AND material health.

On the other hand, the research also identified specific instances where steps to improve embodied carbon negatively impact material health or vice versa. These conflicts highlight the importance of keeping both methods of evaluating products in mind when making material choices.

Conflict——
Opportunities to improve embodied carbon may conflict with material health optimization in the following ways.

Product types that contain PVC.

Product types that contain PVC are among the least preferred from a material health perspective, yet they rank in the middle for embodied carbon impact amongst different product types. Choose product types that are optimized for both embodied carbon and material health.

Alignment ——
The opportunities to improve embodied carbon and material health for flooring are also largely complementary.

Use flooring with a long service life.

The least impactful (most preferred) products from a material health and embodied carbon perspective are the products that you don't need to replace. By selecting a product with a long service life, fewer replacements are needed and therefore the impacts associated with these replacements are avoided.

Choose biobased product types.

Linoleum, wood, and cork are all flooring product types that were identified as both resulting in lower embodied carbon and safer in terms of material health.

Avoid use of virgin nylon carpet product types.

Carpet made with virgin nylon as a generic product type was identified as having the highest embodied carbon[35] within the flooring category and can contain more chemicals of concern than other product types.

Use circular and safe materials.

The use of recycled materials can both lower embodied carbon and re-introduce legacy chemicals of concern. Use recycled content from known sources. Prefer products that have been tested for these chemicals and have below detectable levels or below levels that would be found in virgin resin content for these materials.

Interventions

This case study has used drywall and flooring as examples to identify key drivers of embodied carbon and material health impacts as well as opportunities for improvement. In this section, those same goals are used to define policy instruments that can encourage and reward work towards safer products with low embodied carbon.

Policy Considerations

Regulations on chemical content

Some chemicals that are similar both in structure and function can also share hazards. Such chemicals can be grouped together as a class or compound group. A class-based approach recommends that if known hazards are sufficient to justify restrictions associated with one member of a class of chemicals, then the entire class should be considered for restrictions, exempting individual chemicals only if they are fully assessed and shown to be of low concern. The burden of proof should be placed on demonstrating low hazard and safety of the exceptions. Existing examples of the class-based approach in policy include the U.S. EPA ban on polychlorinated biphenyls (PCBs) and the European Union directive limiting total perfluoroalkyl substances (PFAS) in drinking water.[53]

Regulations restricting hazardous chemicals in a finished product not only can eliminate hazards at all phases of current production, but can also support a commercial afterlife for products as safe recycled content to use in future products. In order for these regulations to be effective at promoting the development and use of safer, low-carbon products, however, they must have a wide reach both in product type coverage and, when appropriate, chemical class coverage.

To illustrate the need for wide product type coverage, consider how orthophthalate chemicals banned in children's products starting in the early 2000s were still being used in consumer and commercial flooring products until only recently. By banning the chemicals in toys but not in flooring, children continued to be exposed to these developmental toxicants (ECHA, 2017, 2018).

Material Disclosure Incentives or Requirements

Full product content disclosures, such as Health Product Declarations, enable informed decision-making during product selection. They help enable the selection of safer materials and also provide much-needed content information that can be used at the end of a product's life to support safe recycling.

The current transparency movement is market-driven by individuals and organizations who are asking for this information. Green building standards such as LEED accelerated materials disclosure by adding a building materials disclosure and optimization credit to LEED V4.0.[54] Organizations such as The American Institute of Architects (AIA) are also helping to promote transparency through voluntary programs such as the Materials Pledge: As of 2020, approximately 100 architecture and design firms have signed a letter stating they will prefer, select, and specify products with content disclosure.[55] While these voluntary programs are a good starting point, regulations at a city, regional, state, or federal level requiring disclosure will increase participation and therefore the impacts of these disclosures.

The importance of transparency extends to end-of-life practices. Policies further requiring or incentivizing standardized material disclosures of all building products, similar to what is required by food labels, could enable a more circular economy. When post-consumer waste streams have fully disclosed content, this can make recycling and universal take back programs more feasible.

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Materials Passports

Building on the idea of materials disclosure, another way to enable a circular economy is to establish a way for valuable materials such as building materials to be tracked, reused, or recycled at the end of life. Materials passports would contain a disclosure of critical information, such as: a product's manufacturer, brand name, color/variation, and all ingredients in the product, along with their location. With this information, when a building is at the end of its useful life, those still useful materials could be identified, tracked, and reused or recycled.[56]

By enabling a circular economy and making it easier to find and reuse materials, the need for new materials is reduced. This, in turn, reduces the embodied carbon and material health impacts of those new materials.

The EU Horizons 2020 project as Buildings as Materials Banks (BAMB) is an example of an initiative that is working toward identifying the information and tools needed to shift the building industry towards a circular economy. They defined a Materials Passport Platform along with best practices to enable reversible design (designed to be taken apart and reused) and business models that could support this effort.[57]

Environmental Impact Disclosure Incentives or Requirements

Similar to material ingredient disclosure, environmental impact disclosure enables informed decision making. As mentioned above, Environmental Product Declarations are one way to report these endpoints. In addition to citing the specific environmental impacts, product-specific EPDs should all include an interpretation section where they disclose specifically where the biggest impacts occur and the steps that have been taken to reduce those impacts. These reporting requirements should be standardized in EPD standards, such as ISO 14000 series EPD standards, to ensure all EPDs include a similar interpretation.

As with materials disclosures, Green Building Standards and organizations like AIA are accelerating transparency through EPDs through their voluntary programs. These programs should further incentivize product-specific, plant-specific, third-party verified EPDs with a detailed interpretation as described in the previous paragraph.

By enabling a circular economy and making it easier to find and reuse materials, the need for new materials is reduced. This, in turn, reduces the embodied carbon and material health impacts of those new materials.

End-of-Life Policies

Creating a flooring with minimal chemicals of concern, lower embodied carbon, and full materials disclosure does not guarantee that it will be reused or recycled. For example, one of the strongest recycling programs for flooring in the U.S. is for carpet, yet only 5% of carpet is recycled in any way (e.g. melted down nylon or polyester into resin pellets or extracting calcium carbonate) and only 0.45% of old carpet is recycled into new carpet.[58] This means that 95% of carpet is burned (often as fuel/energy) or landfilled at its end of use, and another 4.55% percent is being downcycled into other products, which will also likely be burned or landfilled at the end of those products' lives. Strong end-of-life policies can help ensure that materials that can be recycled are recycled into products of equal or higher value. They can also limit the generation of waste and ensure that waste-derived materials without hazardous content are incorporated into new products. Thus, financing efficient collection and management schemes should be prioritized.

An additional pathway to promote both safer chemistry and lower embodied carbon products is extended producer responsibility (EPR). The Organization for Economic Co-operation and Development (OECD) defines EPR as "a policy approach under which producers are given a significant responsibility—financial and/or physical —for the treatment or disposal of post-consumer products".[59] EPR programs, such as those implemented in Korea, Japan, and parts of Europe, have been shown to increase recycling and reduce waste; these programs may also help promote the development of products that are designed for takeback, disassembly, and reuse or recycling.[60]

95% of carpet is currently burned or landfilled at its end of use, and another 4.55% percent is being downcycled into other products, which will also likely be burned or landfilled at the end of those product's lives.

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Specifications

New Construction

In building and construction, a specification is a document describing step by step how a building should be built. This includes stating the specific materials to be used, how those materials should be installed, and how to dispose of waste materials. Specifications are an important tool to use to ensure products that are identified early in the design process as low-carbon, safer materials end up in the final project. Base specifications are generic specifications developed by an architectural firm as a starting point for a new project specification. Healthier, low-carbon products can be added to base specifications to increase the likelihood that those preferred materials will be incorporated into all projects for the firm. These documents can include the “why” of safer, low-carbon materials to educate entire project teams about the importance of these topics and, again, increase the likelihood that those preferred materials will be used.

One challenge with new construction specifications is including guidance on how to maintain, reuse, recycle, or dispose of materials at the end-of-life. Upon construction completion, the buildings are typically owned and operated by a different company, making it difficult to communicate or enforce these instructions. Changing local policies around construction waste to encourage reuse and recycling would help these efforts.

Renovation

Specifications are also used in renovations. These documents can incorporate language and actions for specific materials to promote material recycling and reuse and divert waste from landfills.

One challenge with this approach is that project teams typically do not know what current materials are in the project site to begin with. This assessment of existing materials is not part of the typical workflow for a renovation. Material Passports, as described above, are a long-term solution. Developing guides for the most commonly encountered materials with best practices on reuse, recycling, or disposal would facilitate this process in the short term.

Developing guides for the most commonly encountered materials with best practices on reuse, recycling, or disposal would facilitate this process in the short term.

Data Needs

This research brings attention to the need for more data on the key drivers of material health and embodied carbon for different product types within product categories. HBN's Hazard Spectrum, which compares and ranks different product types within product categories, currently covers mostly interior finishes, with a plan to routinely add new categories. EC3 is currently set up to allow for comparisons of specific manufacturer products that are the same product type. EC3 currently includes most core and shell materials and some interior finishes. More research comparing embodied carbon of different product types within a product category is needed.

This research also highlights the need and benefits for these findings to be available in a single tool. Alignment in the naming or categorization of product types and product categories between different tools will facilitate this effort.

Conclusion

The American Institute of Architects (AIA) Materials Pledge asks members to pledge to support human health, social health & equity, ecosystem health, climate health, and the circular economy. Addressing any one of these topics presents its own set of challenges, and addressing multiple topics is overwhelming to many. Yet, this case study highlights that key impacts can be missed by only tackling one topic at a time.

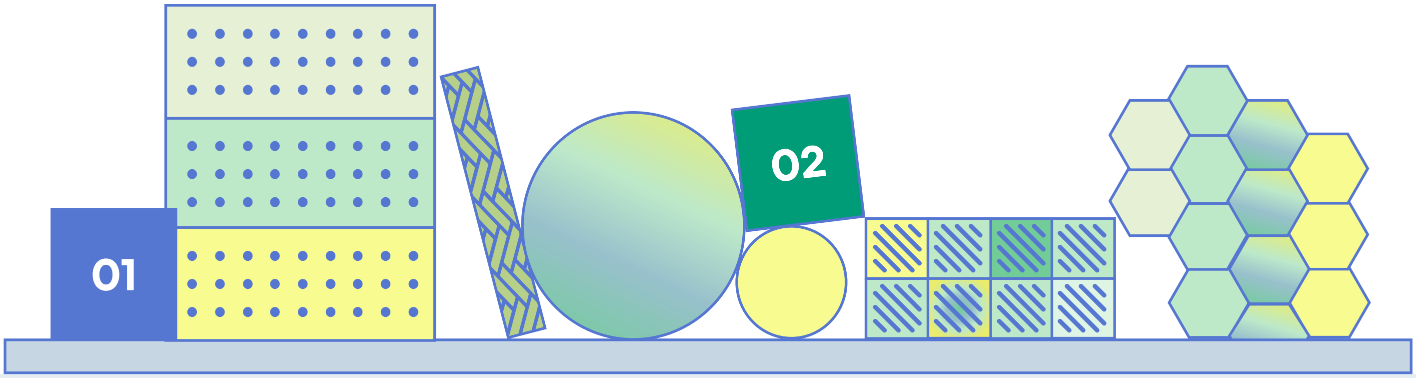
Furthermore, this research also points out the importance of considering different product types within a product category before considering different specific manufacturer products within a product type.

This guidance is based on typical product type content and there may be exceptions with specific manufacturer products. For example, cork click tile flooring may use polyvinyl chloride in the core of the product, which would not be preferred from a material health perspective. For another example, carpet made from recycled nylon or resilient flooring made with recycled PVC may improve that specific product's embodied carbon standing. Additionally, materials like cork, and in some cases wool, have potential to be circular and regenerative because they are tied to ecosystems. This potential is not included within the system boundary of most studies; further research is needed to explore the impacts of these material types across a variety of land management scenarios. With this said, this research is based on data from what is commonly found on the market today for these product types.

This case study was limited to two product categories, and other product categories will differ in the ways that embodied carbon and material health manifest. In the future, similar studies are needed to define the characteristics of low-carbon, safer product types for other product categories.

Steps for Architects/Owners to Select Safer, Low-Carbon Products

Here are some steps that project teams can take to support the development of and use of safer, low-carbon 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 Hazard Spectrum)

Prefer product types with typically lower embodied carbon
(e.g. select product types using Carbon Smart Materials Palette guidance)

Step 02 —— Choose specific manufacturer product

Prefer manufacturers with established take back programs who support transparency, EPR, and are investing in recycling and reuse programs.

Prefer products with an HPD and 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. Choose products that contain less hazardous chemicals than other similar products. Hazardous chemicals can be identified by using restricted substances lists such as Perkins & Will Precautionary List, Living Building Challenge Red List or Green Science Policy Institute Six classes List.[61]

Prefer products with product specific, plant-specific, Type III, third party verified EPD. 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. Choose products that have lower embodied carbon than other similar products using a comparison tool such as the EC3.

We all have a role to play to protect human health and the environment both in our own backyards and in the regions impacted by climate injustices and fenceline communities. The material choices that projects teams make do not have to be either low embodied carbon or safer. They can choose product types that optimize BOTH embodied carbon AND material health. While other considerations including cost, performance, and aesthetics are also part of material decisions, these steps provide actionable guidance to consider embodied carbon and material health when making a product decision.

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Endnotes (continued)

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Endnotes (continued)

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