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DRIVERS AND BARRIERS IN IMPLEMENTING VERIFIED CARBON-NEUTRAL BUILDING PRODUCTS

Asmau Edewede Ikhuoria[1], Jonathan Torres[2], Zia Ud Din[3], Catherine Callaway[4]

[1]Kirksey Architecture, Houston TX 77024, USA, Email: edesi@kirksey.com
[2]Kirksey Architecture, Houston TX 77024, USA, Email: jonathant@kirksey.com
[3]Department of Construction Management, University of Houston, Houston, TX 77004, USA, Email: uziauddin@uh.edu
[4]Kirksey Architecture, Houston TX 77024, USA, Email: catherinec@kirksey.com

ABSTRACT: The latest milestone for building product manufacturers seeking to increase their low-carbon product portfolio and reduce their carbon footprint, is to offer carbon-neutral products that are third-party verified. This involves extensive emission reductions in the manufacturing process, obtaining certified carbon offsets, and having the process successfully audited by a reputable independent organization. Verification involves challenges such as accurately calculating Scope 1 and Scope 3 emissions under the Greenhouse Gas Protocol and procuring sufficient carbon credits, which can limit the number of manufacturers seeking verification. This study explores how interior building product manufacturers are verifying carbon-neutral claims, along with the motivators and challenges identified through in-depth interviews of experts from five companies. The main contributions of this study reveal the impact of management buy-in in adopting sustainable company policies. It examines the levels of progress with tracking Scope 1, 2, and 3 emissions and eventual carbon-neutral status by the companies studied; it references verification organizations that exist for this purpose, the varied approaches these companies are prioritizing in attaining net zero, and the impact of the Science Based Targets initiative (SBTi) and similar bodies on these pursuits. Findings reveal that efforts range from companies attaining carbon-neutral status regarding operational emissions to having no product, one or entire product portfolio, being carbon-neutral verified. It also showed that Scope 1 and 2 emissions are tracked much more frequently than Scope 3 emissions due to associated costs and complexities. Companies can address this by becoming vertically integrated or forming supply-chain partnerships.

1. INTRODUCTION

The global building and construction sector is a significant contributor to greenhouse gas (GHG) emissions, accounting for a substantial portion of global energy consumption and carbon dioxide (CO_2) emissions (UNEP 2024). As concerns about climate change and its far-reaching consequences intensify, there is a growing imperative to reduce the environmental impact of the built environment. This has led to increased interest in sustainable building practices, focusing on minimizing the carbon footprint of buildings throughout their life cycle.

One crucial aspect of this effort is the reduction of embodied carbon, which refers to the GHG emissions associated with the extraction, manufacturing, transportation, installation, maintenance, and end-of-life disposal of building materials (Akbarnezhad and Xiao 2017). Traditionally, green building design has emphasized operational energy efficiency, aiming to minimize energy consumption during the building's

use phase (Cao et al. 2016). However, as operational energy use becomes more efficient due to stricter building codes and the adoption of renewable energy sources, the relative contribution of embodied carbon to a building's overall carbon footprint increases (Pomponi and Moncaster 2016).

In response to this growing recognition of the importance of embodied carbon, building product manufacturers are under increasing pressure to develop and offer low-carbon alternatives. The latest milestone in this trend is the pursuit of carbon-neutral building products (Causone et al. 2021), where the GHG emissions associated with the product's life cycle are reduced to net zero through a combination of emission reduction strategies and carbon offsetting (BSI 2025). Achieving carbon neutrality for building products involves a complex process. It will begin with a comprehensive assessment of the product's life cycle GHG emissions, typically conducted through a life cycle assessment following established standards such as ISO 14040 and ISO 14044 (ISO 2006, 2020). This assessment encompasses emissions from all product life cycle stages, including raw material extraction, manufacturing processes, transportation, use, and end-of-life disposal or recycling.

A key challenge in this process is the accurate accounting of both direct (Scope 1) and indirect (Scope 2 and Scope 3) emissions, as defined by the GHG Protocol (Protocol 2016). Scope 1 emissions are direct emissions from owned or controlled sources, while Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions, often the most challenging to quantify, encompass all other indirect emissions that occur in a company’s upstream and downstream value chain. For building product manufacturers, Scope 3 emissions are significant because they include emissions associated with the extraction and processing of raw materials, transportation of products and eventual disposal or recycling at end of life.

Many product manufacturers are working toward obtaining third-party verification for their carbon-neutral products (Odake and Khare 2023). This process will give an added assurance to their claims. Third-party verification involves an independent assessment of the product's carbon footprint and the measures taken to achieve neutrality, typically conducted by a reputable organization following established standards and protocols. This verification process provides credibility and transparency, assuring consumers and stakeholders that the product's carbon neutrality claim is valid and reliable.

However, the path to achieving and maintaining third-party verification for carbon-neutral building products is not without its obstacles. Manufacturers face numerous challenges, including the complexity of accurately quantifying Scope 1 and Scope 3 emissions, the availability and cost of high-quality carbon offsets, and the need for continuous improvement to maintain carbon neutrality over time (Chehrehgosha Kenari 2024; Willette 2024). There is a need for the evaluation to be standardized and the progress to be measured in line with the protocols. The Science Based Targets initiative (SBTi) developed the first global science-based standard for companies to set net-zero targets, and the SBTi’s Corporate Net-Zero Standard contains guidance, criteria, and recommendations to support corporates in setting net-zero targets to be validated by the SBTi (SBTi 2024).

This research paper will review this concept, examining the drivers and barriers building product manufacturers encounter in pursuing carbon-neutral product verification. This study aims to shed light on key factors influencing the adoption of carbon neutrality practices in the building materials industry by examining the experiences of manufacturers actively seeking or having already achieved third-party verification. The research explores industry trends, innovations, and partnerships shaping the timelines for achieving carbon-neutral products. It will also delve into manufacturers' methodologies and frameworks for quantifying emissions across their supply chains, highlighting the challenges and best practices in this area.

2. LITERATURE REVIEW

The building sector significantly contributes to global energy consumption and carbon emissions, making it a key focus in addressing climate change and achieving targets like the Paris Agreement's goal of limiting warming to 1.5° Celsius (Chen and Ma 2023). Specifically, the building sector accounts for approximately

40% of global energy consumption and carbon emissions (Chen and Ma 2023). Carbon neutrality, aiming for net-zero carbon emissions, has become a critical goal for organizations, governments, and individuals to mitigate climate change and global warming (Koh et al. 2023; Zhao 2022). Achieving carbon neutrality involves reducing GHG emissions and balancing the remaining emissions by removing an equivalent amount from the atmosphere (Koh et al. 2023). This consists of strategies, including reducing emissions, transitioning to low-carbon technologies, and offsetting emissions through carbon credits or sinks (Koh et al. 2023). Given the urgent need to reduce emissions, manufacturers are increasing efforts to develop low-carbon building products, with the latest milestone being third-party verified carbon-neutral products. These efforts encompass substantial emission reductions in the manufacturing process, acquisition of certified carbon offsets with quantifiable impacts, and successful auditing by a reputable independent organization.

2.1 Challenges and Drivers of Carbon-Neutral Building Product Verification

Carbon neutrality lacks a universally accepted definition, and even within the architecture and construction industry, where decarbonization efforts are intensifying, the term “carbon-neutral building" lacks a widely agreed-upon definition (Rayegan et al. 2024). Despite the increasing need for verified carbon-neutral building products, several challenges exist in achieving and maintaining verification (Deng and Lu 2023). These challenges include accurately calculating Scope 1 and Scope 3 emissions under the GHG Protocol (Yoffe et al. 2024) and sourcing sufficient carbon credits (Koh et al. 2023). Maintaining third-party verification across multiple product lines (Chen and Ma 2023). Interoperability problem of multi-source heterogeneous data when evaluating marginal abatement cost (Lu and Deng 2025). Integrating bio-feedstock into existing structures is challenging for industries that aim to substitute fossil feedstocks with bio-based ones for chemical conversion. In contrast, actors downstream in the value chains may have greater flexibility to substitute synthetic products for new bio-fiber-based ones (Bauer et al. 2022).

Understanding the drivers and barriers to achieving carbon-neutral product verification is essential for enhancing participation in decarbonization efforts within the construction industry (Sun et al. 2022). Several factors drive the demand for carbon-neutral building products, including policy and regulatory context. International agreements and national policies, such as Nationally Determined Contributions under the United Nations Framework Convention on Climate Change, drive the need for carbon emission reductions in the building materials industry (Dalton et al. 2023).

2.3 Barriers to Implementing Verified Carbon-Neutral Building Products

Several barriers impede the implementation of verified carbon-neutral building products. Measuring embodied carbon and life cycle emissions in building materials is challenging (Cosentino et al. 2023b). The lack of standardized methods for embodied energy measurement adds to this difficulty (Chen and Ma 2023). Click or tap here to enter text. The complexity of supply chains, with multi-layered processes and global inputs, makes it difficult for companies to benchmark their environmental performance against industry standards or competitors (Koh et al. 2023).

Reinvesting plants and equipment for decarbonization and implementing new production processes can be expensive (Dalton et al. 2023). The limited availability of input data for carbon assessments and a lack of transparency in environmental data hinder the comparison between insulation materials (Yoffe et al. 2024). Achieving carbon neutrality may require extensive installations that exceed building footprints, posing practical challenges, especially in urban areas (Koh et al. 2023).

3. METHODOLOGY

3.1 Research Design Framework

This study focused efforts on companies that produce flooring, wall finishes, and ceiling products, identified as Company 1, Company 2, Company 3, Company 4, and Company 5. This approach was taken to enable

an assessment of how the materials that make up a building's composition individually attain verifiable carbon-neutral status starting from the interiors and thus, cumulatively contribute to the carbon neutrality of a building. An exploratory qualitative research design method using in-depth expert interviews was chosen to understand the complex decision-making processes and challenges in carbon neutrality verification. The research uses semi-structured interviews with industry experts to allow for both systematic data collection and the flexibility to explore unexpected insights.

3.2 Expert Selection and Recruitment

The participants consisted of ten experts from the selected five companies, ranging from senior sustainability officers (regional, national, and global leaders at companies) to local sales representatives or account executives. Specific criteria for expert selection included having at least 10 years of industry experience, direct involvement in carbon neutrality verification processes and sustainability protocols, high decision-making authority within their organizations, and successful verification and in-process verification efforts. These companies were selected for this investigation due to their recognition for being at the forefront of sustainability in the industry and their publicly declared carbon reduction strides.

3.3 Interview Protocol Development

This section outlines our systematic approach to designing and conducting interviews.

3.3.1 Interview implementation

We conducted approximately 60 minutes of virtual meeting interviews using Microsoft Teams. These interviews were recorded and transcribed with the permission of the interviewees. We also utilized Google Notebook LLM, an AI-generative platform for further data transcription. Using Clark and Braun's Thematic Analysis, we deduced common themes that reveal consistent patterns of challenges or barriers, as well as motivators for ongoing carbon-neutral efforts. We were able to assess their progress by meeting internal carbon-neutral goals and industry or global initiatives such as SBTi.

3.3.2 Question design

The interview was crafted, to begin with broad, open-ended inquiries on sustainability, company formation, and sustainability history, which progressed to specific technical details, including probing questions for deeper insights, allowing for reflection and recommendations, and enabling cross-case comparison. These questions include company size, types of products manufactured, and scale of operations.
We curated questions tailored to the objectives of this research for the interviews (see Table 1 below) and shared these with the participants ahead of the interview session to use as a guide for expanding conversations as the interview progressed.

Table 1: Interview questions

Factual	How are you measuring Scope 1, 2, and 3 emissions?
	Which industry commitment/time horizons are you following?
	What were the motivations for pursuing carbon neutrality?
	What is your approach to emissions reporting and data transparency?
Opinion-Based	What challenges have you faced in measuring each emissions scope?
	Do your suppliers pose a challenge to your carbon reduction efforts?
	How active is your company in steering committees and advocacy efforts?
	Has pursuing carbon neutrality impacted your company’s profitability?
Scenario-Based	What was your process to find and evaluate your third-party carbon consultant?

Have you encountered regulatory barriers and/or stakeholder concerns?
Are you seeking carbon-neutral certifications for individual product lines?
What improvements did you target in your manufacturing processes?

4. DATA COLLECTION

4.1 Data Collection Process

Data extracted from each company interview was classified into three main categories: formation and sustainability background, motivation for decarbonization, and carbon commitments & SBTi goals.

4.2 Company 1 Data

Company 1 manufactures carpet tile and resilient flooring with nationwide and international offices. Our participants for this interview section were the Manager of North American Sustainability and the Head of Global Sustainability Strategy, both very invested in the company's carbon footprint reduction. It was founded just over fifty years ago, and according to our participants, sustainability was ingrained as a company purpose before it became widely accepted in the industry. They created an internal accounting system for tracking environmental impacts within the company, called "*econometrics,"* and they made "Mission Zero" - an internal company-wide campaign to have no negative impact on the environment globally.

The participants followed a natural sequence in their pursuit of decarbonization, aligning it with their ongoing efforts to track energy use, water consumption, waste generation, and supply chain activities under the initiative known as "Mission Zero." They shared that, although they didn't specifically refer to it as decarbonization at the time, Company 2 began measuring carbon emissions related to their energy use in the late 1990s. They confirmed that they have been collecting data on the carbon intensity of manufacturing carpet tiles since 1996. The company is committed to reducing carbon emissions by 50% by 2030. They are a signatory of the Climate Pledge, which is their pledge to reach net zero (without offsets) by 2040. They are currently a verified carbon-neutral company, as confirmed by Past 2060 and WAP Sustainability. Additionally, they are committed to the UN Global Compact and the UN-backed Climate Group's "Race to Zero." The company has also reported that its suppliers are increasingly adopting their own carbon reduction goals compared to several years ago.

4.3 Company 2 Data

Company 2 is a wall covering and textile company with multiple offices nationwide in the US and supply chain partners in Asia and Europe. Participants were the Vice President of Sustainability at the company and the local sales representative, who gave us insight into the sustainability practices they have adopted and their recently released first carbon-neutral product. Founded nearly forty years ago, they have made their mark in the commercial interior industry as the largest distributor of textiles and wallcoverings in the US. Our participants discussed their commitment to sustainability from twenty years ago, with efforts toward operational and production practices.

The motivation for achieving carbon neutrality stems from a commitment to sustainability and a desire to foster innovation. Over the past year, they launched their first carbon-neutral product, which consists of 70% bio-sourced materials, including algae, wood chips, and natural fibers. SCS Global Services has verified this product and was produced in partnership with another supplier. In discussing the rationale behind this product, the participant highlighted that one of the challenges with bio-sourced materials is that they are often cost-prohibitive, meaning that many sustainable products often involve a trade-off between sustainability and cost-effectiveness. They aimed to strike a balance by creating a product that significantly advances sustainability and is more accessible for purchase. Since this is the inaugural year of the product launch, carbon offsets were purchased to support its carbon-neutral designation.

Company 2 is making ongoing efforts to track its carbon-neutral levels. They are currently investing in software that will help track these goals and are in the process of completing their first GHG inventory. This is geared toward measuring their scope 1, 2, and 3 emissions and helping them create a baseline for assessing their growth, noting areas for improvement or change, and setting future targets to expand their carbon neutral and general sustainability footprint. They plan to track scope 1 & 2 after this first year of performance, subject to further review after three years. According to our participant sustainability leader, their objective is to provide realistic and verifiable information that is substantial and data driven, not greenwashing claims. As a result of this being a work in progress, they have only been able to commit to the Mindful Materials pledge and not any other global carbon reduction pacts or SBTi's.

4.4 Company 3 Data

Company 3 is a designer and manufacturer of acoustic wall and ceiling products based in the Asia Pacific region. The Sustainability Lead and Sustainability Advisor based in the core facility and the local Account Executive in the US South & Central region took part in the interview. Formed in 1967 as a textile company specializing in manufacturing flooring underfelt, its operations expanded in the 1990s, establishing a global presence and gaining notoriety for its sustainable product lines. Sustainability has long been a core tenet of its operations, stemming from its mission to use environmentally responsible raw materials and improve the efficiency of its manufacturing processes. This company was selected for inclusion in this case study for its achievement of carbon-neutral verification for its entire product portfolio and its global operations. Major sustainability milestones include establishing a zero-waste production line in 1990 and expanding the usage of pre-and post-consumer materials for a closed-loop manufacturing process in 2012.

Climate action is a core sustainability principle, and achieving carbon neutrality as a manufacturer is the main goal. The path to decarbonization began on a project-by-project basis when clients began to request low-carbon and carbon-neutral products. As these requests became more common, it became clear that having all its product lines achieve carbon neutrality would be an advantageous market position. There are various global initiatives they align with to guide its decarbonization efforts. The UN Sustainable Development Goals primarily influenced the company's sustainability strategy, particularly Climate Action, Responsible Consumption and Production, and Sustainable Cities and Communities. SBTi and the Paris Accord are used to determine the targets and timelines for its operational carbon emission reductions. In contrast, the World Green Building Council's Advancing Net Zero program is used to determine their embodied carbon reduction goals, which calls for a 50% reduction by 2030. Achieving carbon neutrality on an operational scale involved increased energy efficiency, greater reliance on renewable energy sources, optimizing MEP-R systems and manufacturing equipment in facilities, recovering manufacturing waste, and purchasing verified carbon offsets.

4.5 Company 4 Data

Company 4 is a global manufacturer of ceiling and wall panels based in the US. The Director of Sustainability and the local Sales Manager participated in the interview. Established in 1860 as a manufacturer of cork products such as bottle stoppers and cork insulation, Company 4 started to incorporate sustainability practices into its manufacturing process in the 1890s when operations rapidly expanded. Pre-consumer scrap cork was reused to make sound-absorbing panels. By the 1920s, Company 4 was producing its flagship ceiling tiles and wallboard offerings. Company 4 was in the process of getting an acoustic ceiling panel product line carbon-neutral verified when the interview was conducted.

As a sustainability pioneer in building product manufacturing, decarbonization represents a natural progression of core principles and long-term objectives. The founder initiated the earliest sustainability efforts during the initial stages of the company's history, well before they became common practices. Having manufacturing facilities located in California subjects them to additional scrutiny for reporting and minimizing carbon emissions and increasing demand from customers for operational transparency and low-carbon offerings provide further justification for committing to carbon neutrality. They aim to reduce Scope 1 & 2 GHG emissions compared with a 2019 baseline and meet 100% of its electricity needs through renewable

sources by 2030. These goals were developed in accordance with SBTi criteria and have been validated by SBTi. They do not currently have a fixed timeline for achieving carbon neutrality on a portfolio or operational scale. Carbon offsets verified according to ISO 14064-3 standards are procured from the GHG CleanProjects Registry. A sufficient quantity of carbon offsets has been procured to achieve carbon neutrality for its low-carbon acoustic ceiling panel through 2026.

4.6 Company 5 Data

Company 5 is both the largest flooring manufacturer based in the US and the largest recycler of carpet tile in the world. They achieved 100% carbon neutrality in their global carpet operations in 2018. Their goal of achieving net zero operational emissions in Scope 1 and Scope 2 by 2030 adheres to SBTi standards. Company 5 became a commitment signatory of the World Green Building Council Advancing Net Zero program in 2018, reporting its progress annually. The overarching goal is to greatly reduce operational and embodied carbon emissions. The four-step process outlined involves improving manufacturing efficiencies, minimizing reliance on fossil fuels, implementing on-site renewable energy generation, and investing in carbon credits. They do not currently have carbon-neutral verification for individual products. They are vertically integrated in their carpet product manufacturing, facilitating supply chain emission reductions. They have heavily invested in renewable energy assets to support their largest manufacturing facilities, reducing Scope 2 emissions directly.

5. DATA ANALYSIS

5.1 Data Analysis Framework

The authors employed Braun and Clark's Reflexive Thematic Analysis (RTA) to systematic code data and identify recurring themes, map patterns across interviews, document unique insights and generate theoretical insights. This system was adopted as a proven approach for deducing empirical results from a qualitative data set (Byrne 2021). Cross-interview analysis were carried out to comparatively examine common challenges and solutions, varying approaches and perspectives, success factors and barriers and industry-wide implications

5.2 Reflexive Thematic Analysis Themes

The codes derived from the analyses were redefined into the following themes:
R1: Global initiatives & commitments - *company-specific goals and initiatives, industry and global SBTi's toward carbon reduction*
R2: Product take-back programs - *any reclamation programs or initiatives to consumers geared toward circularity and reuse of their existing products*
R3: CO_2 verification completed - *third-party verification of either Scope 1 & 2, and/or Scope 3 emissions*
R4: Carbon neutral products – *products with verified carbon emissions associated with the manufacturing of a product have been measured to be balanced to zero, with or without purchasing offsets*
R5: Low-carbon products – *products yet to attain carbon neutral status or verified as such, but with comparatively low carbon level*
R6: Company-wide zero carbon targets – *internally declared company goals or pursuit for full product portfolio carbon neutral status (may or may not have been set-up for third party verification)*
R7: Carbon zero drive initiated by external factors – *an indication of decarbonization being a natural progression of existing sustainability principles or if it was spurred by external forces*
R8: Self-initiated prior to industry demands – *company was an early adopter of decarbonization or pursued this path recently*
R9: Carbon-neutral company – *company operations are carbon neutral across all three scopes*
R10: Vertically Integrated – *manufacturing operations directly control various stages of production and supply chain processes*

Table 2: Reflexive thematic analysis

	Company 1	Company 2	Company 3	Company 4	Company 5
R1 – Global initiatives & commitments	X		X	X	X
R2 – Product take-back programs	X	X		X	X
R3 – CO_2 verification completed	X		X		
R4 – Carbon-neutral products	X	X	X	X	
R5 – Low-carbon products	X	X	X	X	X
R6 – Company-wide carbon zero targets	X		X		X
R7 – Carbon zero drive initiated by external factors	X				
R8 – Self-initiated prior to industry demands	X	X	X	X	X
R9 – Carbon-neutral company	X		X		
R10 – Vertically integrated manufacturing			X		X

Table 3: Drivers and barriers to verification of emissions & carbon commitments

Participant company identifier	Range of years in business	Drivers	Barriers	Industry commitments/time horizon or SBTi goals	Third-party carbon-neutral verifier
Company 1	50 to 60 years	Improvement on existing company metrics for sustainability and carbon accounting; internally set SBTi goals	Cost; scope 3 supply chain control	2030 50% carbon zero, 2040 carbon zero – no offset; signed UN Global Compact, Climate Pledge, UN backed campaign “Race to Zero”	WAP Sustainability (for product & company status) & Past 2060 (for company status)
Company 2	40 to 50 years	Improvement on existing sustainability commitment with data driven declarations	Cost; scope 3 supply chain control	Mindful Materials Pledge	SCS Global Services
Company 3	50 to 60 years	Climate action is a core principle; supply chain conditions are conducive to decarbonization goals	Minimizing reliance on carbon offsets; achieving scope 3 emission reductions	Aligned with SBTi goals, the Paris Accord, and the World GBC Advancing Net Zero program	EKOS
Company 4	Over 100 years	Sustainability is a founding principle; decarbonization is universally supported by internal and external stakeholders	Cost; scale of operations; difficulty measuring, tracking & reducing scope 3 emissions	Has SBTi-validated Scope 1 & 2 emissions reduction goals, but no timeline for Scope 3 reductions	S & P
Company 5	70 to 80 years	Improvement on existing sustainability performance and remaining a leader in its field	Does not have SBTi goals approved yet; minimizing reliance on carbon offsets	Net zero Scope 1 & 2 emissions by 2030 (SBTi); World GBC Advancing Net Zero program & UN Global Compact signatory	Nil

6. CONCLUSIONS

Companies consulted for this study are making ongoing efforts to track their embodied and operational carbon emissions and have all launched certified low-carbon products into the market. Three out of the five companies (Companies 1, 3 & 5) achieved carbon-neutral status (operational emissions from one or all of their facilities). However, this does not automatically mean carbon-neutral status for their products. Company 1 has launched a carbon-neutral product and is working toward eliminating the use of carbon offsets entirely. They no longer want to be called a carbon-neutral company as they transition toward full net-zero status. Company 3 has successfully achieved carbon-neutral status for its entire product portfolio. In contrast, Company 5 is more focused on mechanisms to achieve a similar feat and is not prioritizing launching a single carbon-neutral product at this time. Despite the generality of Scope 3 emissions being an inhibitor to full carbon accounting, Company 1 appeared to express the most progress in-depth of data and methodology with tracking supply chain induced emissions that they can defensively report. This is due to their existing carbon accounting framework, and their internally set standard metrics system for tracking their sustainability efforts. It was also understood that, although Scope 3 tracking remains an ongoing effort, not all downstream Scope 3 emissions categories are relevant to these companies.

Material and product circularity were key contributors to all the manufacturers' decarbonization efforts. Partnering with sustainability-oriented suppliers and manufacturers minimizing their own carbon emissions through bio-based materials is a vital step toward achieving Scope 3 reductions in manufacturer supply chains, as demonstrated by Companies 1 and 2. Vertically integrated companies like Company 5, appear to have more influence over raw material carbon emissions. In cases where companies are not vertically integrated, partnerships with third-party suppliers or manufacturers have proved an effective and faster way to attain carbon neutrality with products.

Notable drivers for seeking carbon-neutral verification include building on existing internal company carbon accounting practices and sustainability principles, having advocated for this in company leadership or management, client and market demands, and pledges to carbon reduction pacts. The barriers noted were cost constraints in executing verification processes, profitability, lack of control over transportation, logistics of finished product, and other dimensions of Scope 3 emissions. This study provides a basis for further investigation into carbon-neutral verification of building materials, as sufficient literature did not seem to exist in this area at the time of this research. The authors recommend industry practitioners, eco-friendly verification organizations, and sustainability champions galvanize toward creating standardized, industry-wide carbon-assessment metrics, building on the GHG Protocol. This, in conjunction with replicable processes for systematically reducing embodied and Scope 3 operational emissions and increased partnerships with supply-chain players at various levels, will allow manufacturers at varying scales of operation to streamline their decarbonization efforts.

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